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ELECTRIC SHOCK FATALITIES.

THE deplorable accidents which recently took place at the Fulham Public Baths, resulting in the death of two of the bathers, once more compel attention to the dangers which, under certain conditions, may exist even where they are least suspected. Until quite lately, electric lighting installations at pressures not exceeding 250 volts were generally looked upon as being practically free from danger to the person, and when ordinary precautions are observed this is certainly the case. From the expert evidence given at the resumed inquest on Saturday last, and reported elsewhere in this issue, it will be seen that in the present instance a number of circumstances had fortuitously combined to bring about the disasters which we so deeply lament. The iron tubes in which the wiring was encased were not metallically continuous from end to end; they were not earthed, apparently, in any way whatever; they were within the reach of any person of average height, and were in contact with the wrought-iron capping used for steadying the slate slabs which formed the partitions between the cubicles, and which, moreover, served to efficiently insulate the framing and tubes from earth; the atmosphere was more or less moisture-laden, and the waste pipes from the baths, capped with gun-metal plates, and immersed in water, formed admirable earth plates. Thus, given the necessary contact between a live conductor and some portion of the "protective" tubing, a deadly snare was laid for the innocent and unsuspecting bather who should provide the last link in the lethal circuit, and who would be most suitably prepared for destruction by the dampness of his hands and feet, and the fact that the latter were either on or close to the earth plate. We may point out that the waste pipe was at the end of the bath nearest to the gangway; the iron pipes were screwed together, and the efficiency of the metallic connection between them was demonstrated by the fact that bathers in various parts of the baths received shocks, and doubtless had an exceedingly narrow escape from sharing the sad fate of the actual victims. The breach of continuity of the pipes occurred at the distribution fuseboard, but the piping was only accidentally earthed beyond this point, so that even if it had been continuous it is possible that the results would have been the same. The one precaution, therefore, which was essential and sufficient to ensure absolute safety, was the *efficient earthing* of the whole of the tubes. Seeing that this was an obvious and customary proceeding, its omission in this instance is most regrettable; admitting that the accident was one, the possibility of which the most far-seeing might overlook, the fact remains that it ought to have been impossible, and it would have been so if ordinary good practice had been followed. The Phœnix Fire Office rules, under which the building was wired, specifically state that the tubing should

be earthed, and had they been complied with, these lines would never have been written. As the new Institution Wiring Rules, *when* issued, will doubtless be regarded as the standard rules of the trade, it is to be hoped that the conditions of safety for tube wiring will be clearly defined therein.

It is worthy of note that the fault is said to have occurred, not in the tubes, but in the lampholders, showing that in spite of the many and wonderfully ingenious improvements which have been effected in the construction of these accessories, they are not yet perfect. The situation of the second earth which was necessary to complete the circuit was not, we believe, discussed; but it was doubtless external to the building, and might have occurred anywhere in the same distributing network. Most probably the general leakage inseparable from a widely extended system of mains and installations would fully account for it.

The fact that it was found impossible to release the first victim of the accident from the metal capping until the pressure was cut off, and that one of the other bathers who received a shock released his hold only with great difficulty, indicates that the shock produced muscular fixation, rendering the sufferer helpless. This is, doubtless, due to the alternating character of the current, and possibly might not have occurred had direct current been employed. It was suggested by the doctor who gave evidence at the inquest that the actual deaths took place at the moment of the "extra current," due to breaking the circuit at the fuseboard. But why should there be an extra current? The self-induction of the local circuit would be negligible, and moreover, as the current was alternating, the probabilities are in favour of the actual interruption having taken place when the current was small or zero, so that this suggestion was somewhat ill-founded.

As for the voltmeter test put in evidence by Mr. F. H. Medhurst, the fact that the reading was 165 volts, while the supply pressure was 200 volts, merely proves that the resistance of the voltmeter in parallel with the various leakage paths to earth from the system of tubing, was of the same order as that of the fault; the current flowing through the voltmeter and leakage paths was large enough to cause a drop of 35 volts over the resistance of the fault or faults. As was pointed out by Mr. Ram at the inquest, an electrostatic voltmeter should have been employed for the test; but even then, the reading would have shown only what the pressure was *before* the man provided a new path to earth, and it would still have been impossible to say whether the actual shock to which he was subjected was one of 150, 100, or even only 50 volts. It is on record that a man has been killed with an alternating current shock at a pressure of less than 100 volts.

It must not be supposed, from the occasional occurrence such misadventures, that there is anything inherently dangerous in the use of electricity; in fact, their rarity is in itself strong evidence that on the whole there is no danger to be feared. We scarcely need refer to the liability of such simple and apparently innocuous apparatus as the humble kitchen boiler to explode at times, while the numerous fatalities by suffocation, fire, and explosion incidental to the use of gas do not seem to materially influence public opinion. But nevertheless, every effort should be made to guard against such disasters.

It has been suggested that by the use of pendant fittings the danger would have been obviated, and this is doubtless the case; but, on the other hand, the danger was not foreseen, and the circumstances were not favourable to this practice. The roof is of open iron and glass work, and affords no facilities for supporting the pendants, while the latter would probably have provided a path for condensed moisture to flow down, a condition highly detrimental to good insulation. Moreover, it is essential that each lamp shall be provided with a switch, to economise in electricity when only one or two cubicles are in use, and this would have caused considerable extra cost. It is difficult to imagine a system more secure in every respect than the one adopted—provided that the protective tubing is earthed. The jury apportioned no blame to anyone, and therefore neither can we; we hope, however, that the lesson will be laid to heart by all electrical engineers and contractors in carrying out future work, and that immediate steps will be taken to put in order existing installations.

Fires Caused by Electricity.

Of ever-increasing value are the quarterly reports of the Electrical Bureau of the National Board of Fire Underwriters (America). These have now reached their 37th issue, and each is illustrated by photographs of material or apparatus which have given rise to trouble. It is a coincidence that the 37th report should record 37 cases of fire due to lightning, 19 of which were due to direct flashes, and the remainder to wires not efficiently protected. In all, 164 electrical fires are reported for the quarter, of which the greatest number, 45, was due to accidental earthing of conductors; crosses between overhead lighting and telephone wires with trolley wires account for 20 cases, and the same number is put to the debit of defective wiring; five cases each are due to arcing of motor commutators, to shorts in flexibles due to abrasion, and to overheated resistances in tramcars.

The November number of *Insurance Engineering*, N.Y., reproduces the photographs, and contains a very pertinent article upon the whole question of the inspection of electrical work, and the enforcement of rules appertaining to it. It is impossible to conceive of worse work than is shown in the illustrations.

It is bad enough to find unsoldered joints, but these examples include high pressure wires merely hooked loosely together and laid quite bare in wood casing, plaster and tubing. In some cases the wires are twisted together, and the wireman (!) has evidently thought that so long as one wire was made fast to the other, it was immaterial whether he twisted it round the copper or the insulation. So he has put a few turns round each.

The jerry wireman is not a purely American product. This, unfortunately, is one of the lines in which our trans-Atlantic cousins can claim no monopoly, and we stand on common ground in demanding, for the public good, his suppression.

Granted that there is great lack of uniformity in wiring rules, granted that some are obscure, that others are extreme, and others absurd and unworkable, nothing can be clearer, nor can we wish for more unanimity of opinion than is to be found as to the method of jointing conductors. And yet, in spite of all this, and notwithstanding Electrical Trades Unions, work such as is mentioned above not only can be found, but is far from uncommon.

Speaking of contractors who permit such work—contractors "who carry their offices in their hats; their

consciences they leave at home; who, like the rest of the wicked, flourish for a time"—*Insurance Engineering* adds: "How they manage to make a living out of their work is a mystery."

But there is no mystery about it. They do not *make* a living; they *steal* one. Ask the honest contractor who has to compete with them for work, or the supply house from whom they buy—no, *obtain*—their goods, how they do it. Ignorant of their work, and undertaking contracts at prices below that of the raw material, they obtain goods on credit, employ low-priced and incompetent labour, and live on such advances as they are able to get on account, until bankruptcy or an equivalent steps in and stops their career. By cutting down with their unfair competition the prices of good work, and by obtaining goods which they never pay for, they live a parasitic life at the expense of the trade generally. Yes, *parasite* is the only word that describes them.

And what can check this parasitic growth? Surely not a heterogeneous mass of more or less impracticable rules, based, perhaps, on the fads or fancies of an assistant distributing engineer, and backed up by no more authority than mere bluff. We must have something authoritative, something which can be enforced; we must have compulsory inspection, and the registration of electrical contractors and of wiremen. The extending or altering of installations after being passed should be prohibited, and it should be no more permissible to overload a safety fuse than the safety valve of a boiler.

There is urgent need for action in these matters.

The Toronto Niagara Scheme.—Our Niagara Falls correspondent writes:—"The application of the Toronto Niagara Power Co. for a franchise privilege to develop 100,000 H.P. in Queen Victoria Free Park, on the Canadian side at Niagara Falls, has opened anew the discussion in regard to the extent of the development at Canadian Niagara. On the evening of Friday, December 19th, a hearing on the application was held in the Parliament Buildings, in Toronto. Among those who appeared as interested in the prospective action of the Government on the application were representatives of the Toronto Niagara Power Co., the petitioning company, the Canadian Niagara Power Co., the Ontario Power Co., and the Niagara Falls Park and River Railway Co. The subject was presented in the form of a report from the Park Commission, which advocated the granting of the petition of the Toronto Niagara Power Co., and it would appear from this report that the new company contemplates a development on lines very similar to those of the Canadian Niagara Power Co., which is by means of a wheel-pit and tunnel tail-race. The report expressed the opinion of the Commissioners that the granting of the privilege would not interfere with the rights of any of the present companies, and in this contention they were supported by the opinion of engineer J. J. R. Croes, who held that the contemplated work of the company would not divert the flow of the river away from the intake of the Canadian Niagara Power Co., nor would the taking of 11,200 cb. ft. of water per second from the river appreciably lower its level. Inasmuch as the Ontario Power Co. contemplates establishing its forebay and intake far above the point where the Toronto Niagara Power Co. seeks to tap the river, that company was not much interested in opposing the grant. However, the Canadian Niagara Power Co. representatives recognised in the contemplated grant serious menace and danger to the great works they are now erecting in Victoria Park, and on which they are expending millions of dollars. The question hinged on whether or no the inlet works of the Toronto Niagara Power Co. would, or would not, affect the water level and water supply of the Canadian Niagara Power Co. One side contended that it would, while the other side was equally positive that it would not. In order to illustrate how reasonable was their contention, the Canadian Niagara Power Co. pointed out the remarkable effect of the wing dam erected by the Ontario Power Co., which has had the effect of diverting the entire flow of that portion of the river from about the Dufferin Islands. Premier Ross requested that the contentions of the opposing sides be submitted in writing at the earliest time, stating the Government would then obtain disinterested expert opinion before giving answer."

Muirhead Wireless System.—The Muirhead wireless telegraph system on the *Vedamore* steamship, which arrived recently at Baltimore, Md., is reported to have shown off well in tests of 300 miles off Holyhead.—N.Y. *Electrical World.*

FAULT LOCALISING ON TRAMWAY SYSTEMS.

By A. JOHNSTON, A.I.E.E.

THE desirability of having some method of localising faults on the overhead wires (or conduits as the case may be), and feeders from the generating station of a tramway system, was pointed out by the present writer in the ELECTRICAL REVIEW, January, 1900, where a means of doing so was described which, though somewhat costly owing to the necessity of having pilot wires for every half-mile of line, was accurate in results. Mr. M. B. Field described a method supposed to do the same thing in a paper which he read before the British Association at Belfast recently, but it is very uncertain whether the results of his tests would be of any value or not, as the resistance of the fault has to be allowed for; this varies widely. Another way of testing is depicted in the ELECTRICAL REVIEW, December 5th, 1902, the principle of which is almost the same as Mr. Field's method, and has the same serious objection which renders it unreliable.

A good system of testing is shown in figs. 1 and 2, by which means the position of a fault can be found with a fair degree of accuracy and rapidity, the only delay being

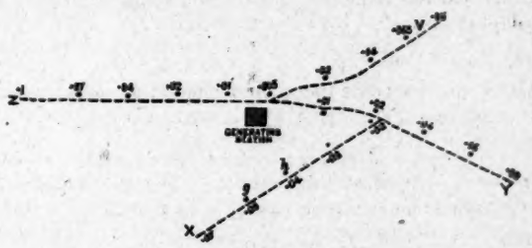


FIG. 1.

caused by the necessity to divide the reading on the testing voltmeter into the value of the testing current and then refer to a chart before the position can be found, but any educated boy could do this in a very few minutes.

The testing current is limited by any auxiliary resistance, but should be comparatively high so as to get an appreciable reading on the voltmeter, one terminal of which is permanently connected to the auxiliary bus-bar, the other being put to the far end of the feeder to be tested by means of a pilot wire laid for the purpose. The cost of these pilot

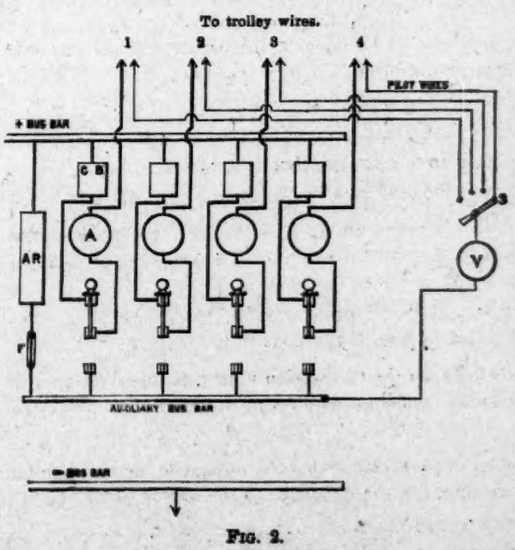


FIG. 2.

wires is the chief objection to this method of testing, but if they are put in at the same time as the other cables, the time saved should soon pay for this; one such pilot wire

is necessary for each terminus, at which place they are connected to the trolley wires, preferably through fuses. The arrangements in the station depend on whether the mains are connected to one another outside or not. It is usual that they are not, as, should a "short" occur, it will then only affect the one particular section that it is on. The connections for testing such a tramway as is shown in fig. 1, are given in fig. 2, by which it will be seen that all of the four feeders are brought to ammeters, and these are connected to the hinges of single-pole change-over switches. The ordinary working position of these switches is on the upper contacts; the feeders are then connected through circuit breakers direct to the positive bus-bar, but if a switch is changed over to the bottom contact that feeder will then be connected to the positive bus-bar, through an auxiliary resistance A R which, if there is a "short" on the feeder, will keep the current down to a reasonable figure.

It is advisable, as already stated, that this current should be large so as to get a distinct reading on the voltmeter, but if too large it is liable to do harm in the way of burning through a trolley wire or destroying a length of cable; 50 to 100 amperes, however, should be safe enough. Should the mains be connected outside the station, it will only be necessary to have a change-over switch for the feeder that is connected to the trolley wires at the nearest point to the station, the other feeders having ordinary single-pole switches, which must be opened during the testing. A map is made out to a large scale of the tramway lines and feeders, and the resistances of the latter are marked at all points where they alter in sectional area and at junctions, such as feeder pillars, &c.

This map should be framed and hung in a handy position for reference. In noting the resistances care should be taken that there are no loose connections in the section pillars to heat and cause the resistance to vary. A good way to guard against this is to take the resistance of each feeder or section before the cars start running in the morning and again after the last car comes in at night. The latter

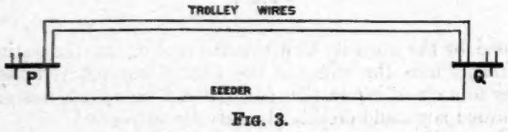


Fig. 3.

result will of course be a little higher than the former, and if the difference is considerable there is undue heating somewhere, which must be remedied before finally filling in the resistances on the chart.

When a fault occurs the switch of that section is put on the bottom contact, the low reading voltmeter marked V in fig. 2 is put between the far end of the feeder and the auxiliary bus-bar by means of the small multiple way switch S, thus showing the drop in volts along the feeder (and the trolley wires, if they are connected in parallel with the feeder) to the fault, this drop is divided by the value of the current shown on the feeder ammeter, and the map is then consulted to find the position of the fault.

Thus, suppose the ratio E/C or the resistance is found to be ·045, it is evident by the map, fig. 1, if the fault is on the feeder running to X that it is between the points h and g, and further it is $\frac{\cdot045 - \cdot04}{\cdot05 - \cdot04}$, or half of the distance from h to g. Even though the trolley wires and the feeders are connected in parallel the fault will always be $\frac{y}{x}$ of the distance between the two section pillars, provided that all three conductors remain unbroken, or if broken, that both ends at the fracture make contact with earth, where x is the resistance from one section pillar to the next (the fault being known to be between these two), and y the ratio E/C found by testing, less the resistance to the section pillar nearer the station.

This will be seen by referring to fig. 3, which represents two trolley wires and the feeder between two section pillars marked P and Q. Let the resistance of any two of these three conductors be r_1 and the resistance of the third be r_2. The testing current of C amperes is run from P to Q, giving a volts drop between these two points. A fault will be assumed on the third conductor, and its resistance from Q, the further section pillar, to the fault is r_3; the current in the first instance flowing along the two wires, or a wire, and the feeder will be—

$$C \frac{r_2}{r_1 + r_2},$$

then

$$a = r_1 C \frac{r_2}{r_1 + r_2},$$

but

$$x = \frac{a}{C}; \therefore x = r_1 \frac{r_2}{r_1 + r_2}.$$

When testing with a fault on, the current is then run from P to the fault; its value through the two good conductors will be

$$C \frac{r_2 - r_3}{r_1 + r_2},$$

and if the drop in volts from P to Q is b, then

$$b = r_1 C \frac{r_2 - r_3}{r_1 + r_2},$$

but

$$y = \frac{b}{C}, \therefore y = r_1 \frac{r_2 - r_3}{r_1 + r_2},$$

from these results

$$\frac{y}{x} = \frac{r_2 - r_3}{r_2}.$$

This will represent the fraction of the conductor's length that the fault is from P, as it is of the same section from P to Q. The current in the second case need not be the same as the first, for should it vary the value of b will vary in proportion, and the ratio b/C or y will remain constant.

A similar method of testing is to take the drop in volts on the rails instead of on the feeders; the results would not be so accurate, as the current may flow along a water or gas pipe some distance before it enters the rails, but they should be very useful, and could be applied to most existing tramways without running any extra pilot wires, as there will already be wires run to each terminus and connected to the rails for the Board of Trade recording instruments. The arrangements in the station will be the same as fig. 2, except that the testing voltmeter is connected to the negative instead of the auxiliary bus-bar. It would be necessary, however, when testing, to open all the feeder switches, closing only the one connected to the feeder with the fault on it, downwards; the current from the cars on the other sections, if left on, would also return by the rails and make the results erratic.

Whether the rails or feeders are used, the resistances to the various points are best found by experiment; this can be done by temporarily connecting the trolley wires to the rails at these places, one at a time, noting the current and taking the drop in volts. This, of course, could not be done while the traffic was on.

ELECTRIC POWER TRANSMISSION IN A CUBE SUGAR FACTORY.

After scarcely 15 years' working, during which period many investigators have been at work and steady improvement has been made, there is now hardly a branch of power transmission which has not been invaded by the electrical engineer.

In power transmission schemes each case must be treated on its own merits, and the special requirements of each necessitate special methods to meet them. We may instance the electric driving of printing machines in the textile and paper industries, and of pumps and ventilators for mines, each case calling for special attention with regard to output of motors and speed regulation. In the great majority of cases, owing to its great adaptibility, electricity has proved itself to be an ideal driving force, and it is now usual, where a new industrial undertaking is being formulated, to adopt it from the first as the motive power.

The following is a short description of the application of electric driving in a cube sugar factory in Bohemia; the part of the factory to which this method of driving has been

applied is an extension of the old sugar factory, and in arranging it the limited amount of space available had to be taken into consideration.

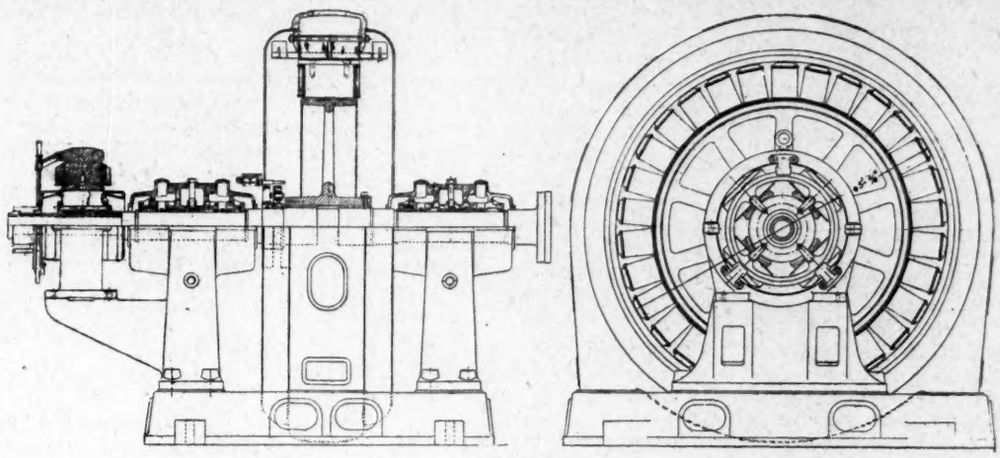


Fig. 1.

The mechanical equipment of this modern factory, with a capacity of 18 to 30 tons of assorted cubes per day, has been carried out under the Huebner-Shroeder patents by Messrs. Bretfeld, Danek & Co., of Prague, while the entire electrical equipment has been supplied by Messrs. Kolben and Co., also of that city, whose interests in this country are in the hands of Messrs. Witting Bros., Electrical Engineers and Contractors, Ltd., London.

To meet the requirements of the centrifugal machines mentioned below for drying the sugar, the three-phase system

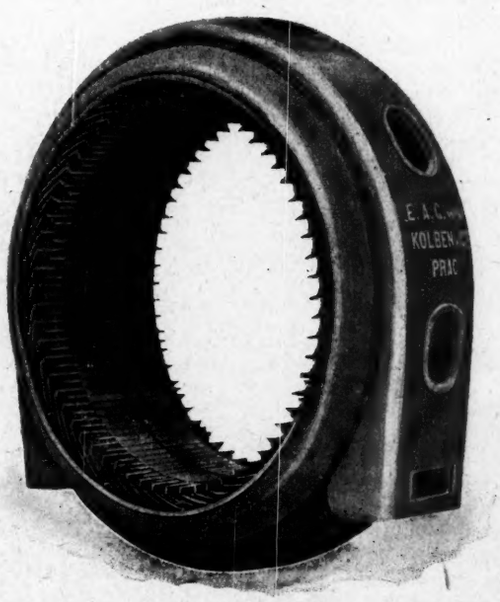


Fig. 2.

was chosen, and in order to obtain the correct speed for the motors driving these machines, the frequency was fixed at 50 cycles per second.

The three-phase generator (a section of which is given in fig. 1) is direct coupled to a vertical steam engine running at a speed of 200 revolutions per minute, and gives an output of 120 (true) KW. at a pressure of 200 volts at the terminals. This machine is of the revolving field type, the cast-steel magnet-wheel carrying 30 steel poles of oval section. The magnet coils are wound on gun-metal bobbins, and are kept rigidly in place by the solid pole shoes.

The stationary armature is built up of stampings 16 mils thick, and is held in a strong cast-iron casing, as shown in fig. 2. The windings are carried in 180 partially closed slots, and consist of copper bars insulated from the surrounding iron by micanite troughs; these copper bars are bent to shape previous to winding, and are connected up in star form.

Fig. 3 shows the no-load characteristic and short-circuit current curves of the generator, which is designed to drive

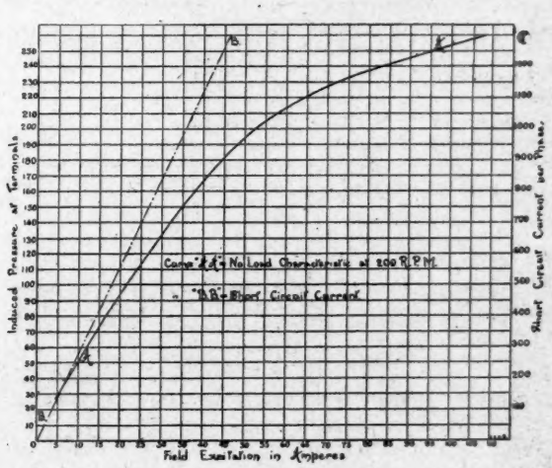


Fig. 3.

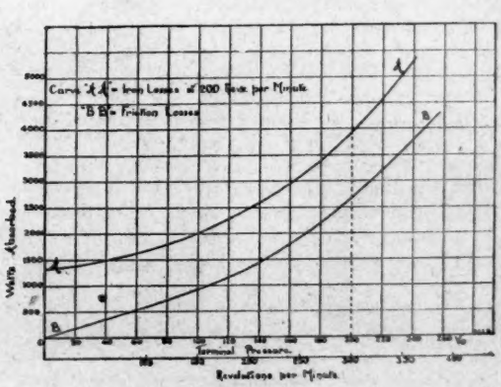


Fig. 4.

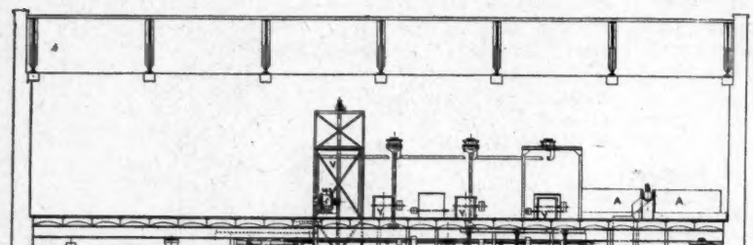
three motors operating centrifugal machines. As the latter might at any time be all switched in at once, this would mean a momentary current of 240 amperes per phase. In consequence, the pressure drop of the generator had to be kept as small as possible, and the curves of fig. 3 show that the drop between no-load and full-load, with a power factor of 80 per cent., amounts to only 18 per cent., taking the

excitation and the speed as constant. Curves showing the iron and friction losses are given in fig. 4.

The following is a table of the total losses in the generator at full load :—

Friction and ventilation losses	1,300	watts.
Iron losses	2,600	"
Armature copper loss	1,500	"
Excitation loss	1,900	"
Total loss in exciter	450	"
Total loss in generator and exciter ...	7,750	watts.
Full load output	120,000	"
Total...	127,750	watts

$$\text{Efficiency at full load} \quad \ldots \quad \ldots = \frac{120{,}000}{127{,}750} = 94\,\%$$



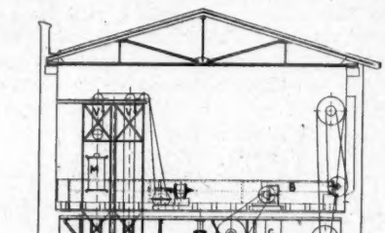
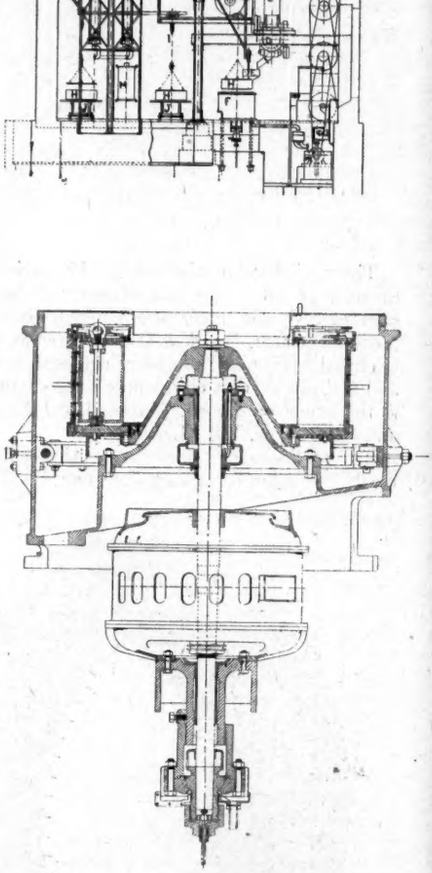


FIG. 5.



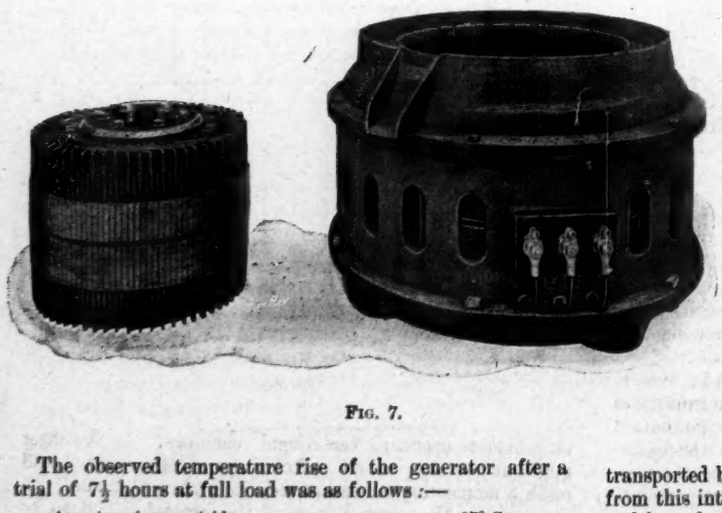


FIG. 7.

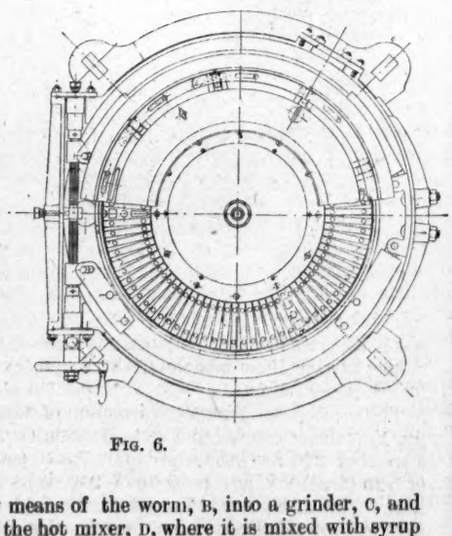


FIG. 6.

The observed temperature rise of the generator after a trial of 7½ hours at full load was as follows :—

Armature iron, outside	27° C.
Armature iron, inside	24° C.
Magnet copper	21° C.
Armature copper	22° C.

The general arrangement of the factory is shown on fig. 5, and the operations carried out are as follows :—

The mass produced in the refining vacuum is lifted by means of a pump into five cooling vats, A. It is then transported by means of the worm, B, into a grinder, C, and from this into the hot mixer, D, where it is mixed with syrup and heated. The electrically-driven centrifugal machines, F, are placed below this mixer, and are filled by means of the hopper, E, with the warm mass, which is then centri-

fugally treated. When the centrifugal machine reaches a speed of 500 revolutions per minute, the mass is covered with syrup and liquor, and is afterwards dried at the full speed of 950 revolutions per minute. The waste product thrown off by the machine is pumped back by means of the syrup pumps, G, to be treated again. The operation of separating the sugar in these machines occupies about 10 minutes, running at full speed.

The drum, H, with the separated slabs of sugar, is lifted out by means of the blocks and tackle, I, and placed upon the trolley, J, while another empty drum lying on the trolley is placed in the centrifugal machine, which is again ready to start up. This operation requires very little time, and the fact that each centrifugal machine is provided with two such drums enables the process of manufacture to be carried on continuously.

The electrical driving of the centrifugal machines required careful study, especially with regard to the starting, and also required a special construction of motor. The latter has six poles, and when fully loaded runs at a speed of 950 revolutions per minute on the 200-volt 50-cycle circuit. The rotor is permanently short circuited, and is keyed directly to the vertical shaft of the centrifugal machine. The stator is carried on an extension of the lower bearing of the machine, and is also fixed concentrically by that means, as shown in fig. 6. Fig. 7 shows the stator and rotor previous to erection.

As the motor has to accelerate the mass of the centrifugal drum with its contents, which is considerable, it takes about six minutes to run up to speed. It has been found that this slow acceleration is valuable under the present conditions, as it assists in mixing the mass of sugar and syrup whilst running at the lower speeds.

The use of a polyphase motor with short-circuited rotor is thus an ideal solution of the problems occurring in this operation of sugar refining. The curves of fig. 8 show the characteristic of the motor whilst starting, and these are of

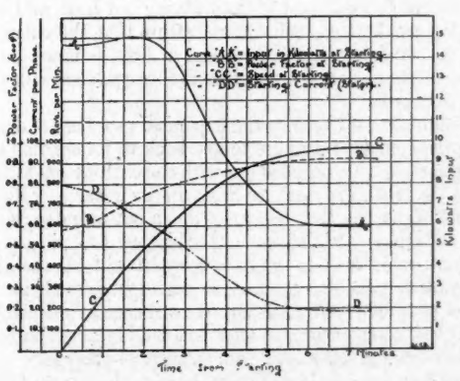

Curve "A" = Input in Kilowatts at Starting.
"B" = Power Factor at Starting.
"C" = Speed at Starting.
"D" = Starting Current (Boiling).
Power Factor (Amp)
Revs. per Min.
Kilowatts Input
Time from Starting
Minutes

FIG. 8.

considerable interest. At the moment of starting the motor has an input of about 15 KW., while at 950 revolutions per minute—the full speed—the input is only 5·8 KW., that is to say, a little more than one-third of the input at starting.

The short circuit current of the motor, which is in this case identical with the starting current, amounts to 80 amperes, while the normal current at full load, 950 revolutions per minute, is 18 amperes. The power factor rises gradually from about 60 per cent. up to 91 per cent. (fig. 8).

No solder has been used in the rotor or stator connections on account of the considerable rush of current at starting, while, as the insulation between the stator winding and the iron is of micanite, the motor can be greatly overloaded without being damaged. The factory works continuously day and night, each motor being started up about four times during the hour, and therefore special attention had to be given to the severe starting conditions. The number of motor-driven centrifugal machines installed up to the present is three, while there is room for five more.

After the drums are removed from the centrifugal machines they are taken to pieces, and the slabs of sugar contained therein are distributed in the suspended trucks, M. After being put together on the trucks on the platform, the empty drums are transported to the water tanks, N_1 and N_2. They are dipped by means of the tackle at O, first into tank No. 1, which contains warm water for cleaning, and then into tank No. 2, which contains cold water, after which they are ready for further use.

The slabs of sugar are transported by means of the trucks, M, mentioned above, to the drying rooms, P_1, which are capable of dealing with 30 tons per day, and are heated by means of hot air.

The electrically-driven fan, Q, forces hot air from the four radiators, R, into the drying rooms, while a second electric fan, T, exhausts the moist and cool air.

After drying, the slabs of sugar are brought by means of the electric hoist, V, to the first storey, in which are placed the band saws, X, and the cube cutters, Y. The electric hoists shown in fig. 5 deserve a word of description.

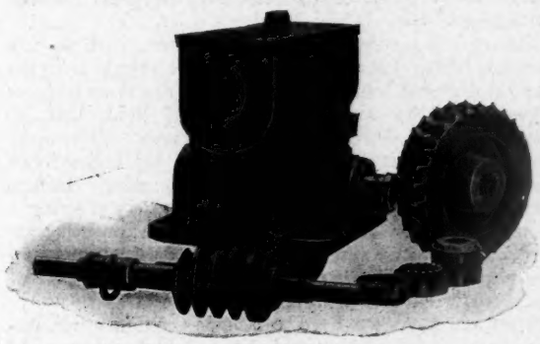


FIG. 9.

Owing to the limited amount of space available, these had to be made as compact as possible. The electric motor drives a worm gear by means of a flexible coupling, which, at the same time, serves as a brake disc. The gear wheel is made of phosphor bronze, and the worm of hardened steel, the whole gear being enclosed in a cast-iron case and running in oil. Ball bearings are used for the worm, the general arrangement of which is shown by the photograph of a similar worm given in fig. 9. The efficiency of the worm gear is 90—91 per cent. at full load. Upon the gearing shaft is keyed the rope drum, which carries two ropes, there being two cages in the lift. A chain wheel has been placed on the drum shaft, which drives, by means of a chain, an automatic switch with screw spindles and nuts, thus stopping the hoist automatically at the end positions. An automatic safety device on the middle position of the controller has been combined with the above arrangement, which secures a sufficient margin for braking and prevents the so-called "over-reversing" of the starter. There is, in addition, an arrangement for switching out the hoist automatically if any of the ropes become slack. The whole gear is mounted on one cast-iron bedplate.

The band saws, X, mentioned above, cut the slabs of sugar produced by the centrifugal machines into strips, which are afterwards cut into cubes by the cutters, Y. Each cutter has a packer, Z, attached to it, which packs the cube sugar produced into cases of ½ or 1 cwt., or into cardboard boxes of 10 lbs.

The machines designated by B, D, and G in the arrangement of the factory are driven by a single electric motor, M_1, while the machines X and Y are driven by another motor, M_2. The whole installation has now been operating without a hitch for over a year.

London—Brighton.—Last Saturday was issued the text of a private Bill for next session, for the purpose of obtaining Parliamentary authority for the construction of an electric mono-rail line between London and Brighton for express traffic. Its length will be slightly over 49 miles. The capital of the company will be £4,500,000. Among the persons mentioned in the Bill as forming the company are the Earl of Dysart, Mr. G. C. Montague, M.P., and General Sir F. Forestier-Walker.

ENTROPY.

By J. SWINBURNE.

It is strange that after half a century there should be any difference as to the meaning of the term entropy, or the idea that underlies it. Yet there is no doubt great confusion in the minds not only of people who have not paid any special attention to thermo-dynamics, but among those who write on thermo-dynamical subjects, such as the steam or gas engine, and among physicists, and even in extreme cases among specialists in thermo-dynamics.

Beyond explaining how the entropy is found mathematically in reversible changes, treatises on thermo-dynamics seldom discuss entropy, or attempt to give any sort of notion of the idea it represents. It may, perhaps, be some use if I give as well as I can, in my own words, my idea of the entropy of Clausius and the great thermo-dynamicians.

Energy exists either in the higher forms, such as mechanical, electrical, magnetic, or chemical energy; or in the lower or degraded form of heat. Heat in this sense includes diffused, and to some extent directed light, heat, or electric radiation, but for simplicity we need only concern ourselves with ordinary heat. Energy in the higher forms can be interchanged from one form to the other. In fact, there is always some degradation into heat in effecting a change, but by choosing suitable means we can make the percentage degraded very small, and can, for convenience of thought only, imagine it zero. Energy of the higher grade can, however, be wholly degraded into heat.

Heat, on the other hand, can, under certain conditions, be almost wholly converted into a higher form; by choosing suitable arrangements, nearly the whole can be thus elevated, and in imagination, for purposes of convenience of thought only, it can be wholly elevated. But this elevation can only be brought about by some change in a body, and that body can only be brought back to its original state by degrading some energy from a higher form into heat again. For instance, if we have the ordinary perfect gas and cylinder of the text-books, we can let the gas absorb heat and give out higher grade energy to approximately the same amount, and we can imagine the process frictionless, and think of the whole of the heat being converted into mechanical energy. But the gas is in a different condition at the end of the process, as its volume is greater and its pressure less. To get it back to its original state it must be compressed, and that degrades mechanical work down into heat. Thus if the gas is to be used over and over again for converting heat into mechanical energy it must sometimes take in heat and sometimes give it out. The question of importance is, What relation has the heat turned into mechanical work to the work degraded back to heat? Carnot thought at first that heat was taken in at a high temperature, and that the same amount was given out again at a low temperature. Clausius found that a quantity which he called entropy took practically the place originally ascribed to the heat. He found that in a reversible Carnot cycle the working fluid gave out the same entropy at the lower temperature that it took in at the top, the entropy being numerically equal to the heat divided by the temperature, so that in a reversible cycle the hot reservoir lost the same entropy as the lower one gained. But he did much more than this, he showed that in all changes in nature there must be an increase of entropy.

Coming back to the gas in the cylinder, suppose we have a heat reservoir which gives the gas 100 joules at a temperature θ_1, of say 500°. Let us neglect friction and such things, and assume that the gas is "perfect." It expands isothermally, and in doing so it converts the 100 joules from the lower form of heat to the higher form of mechanical energy. It may work a machine, which thus gets 100 joules. The gas has taken no energy. We have thus converted 100 joules of heat into 100 joules of work, but we have not left the gas in its original state; it is in a less useful state. To bring it back to its original state, so that it may be ready to be used again in the same way, we must convert work back into heat. We want some way of labelling the expanded gas to show that it is not in such a good state. We, therefore, say that its entropy is increased. Taking the original state as our zero of entropy, the entropy ϕ_1, of the expanded gas is a sort of brand, which signifies that the gas cannot be got back to its standard state without being purged of that amount of entropy. Entropy is a function that can never be reduced. In fact, it always increases, but for the moment we can imagine the gas to be compressed reversibly. Another way of saying that entropy cannot be reduced is to say that it can only be given out by giving out heat, so that the increase of entropy of the body that receives the heat is at least as great as the decrease of the entropy of the body losing entropy. Another way of putting this is to say that a body cannot give off heat to another of higher temperature. If it did, the receiving body's entropy would increase less than the giving body's decreased, so there would be on the whole a decrease of entropy. Our perfect gas, after its expansion, is thus branded with the entropy ϕ_1. If the gas expanded reversibly at temperature θ_1, or 500° C. absolute, as it took in 100 joules, its entropy is 0·2 in scientific units. But it must not be supposed that the entropy is a factor of heat. The energy is not held by the gas; it has gone on to the machine, where it has its own factors; the temperature and entropy of the gas cannot be factors of energy that is not in the gas, but elsewhere under its own separate factors. This is a mistake that many writers make.

Suppose the gas had been allowed to expand by being blown into a vacuum. No external work would have been done, and no heat would have been taken in, as Joule showed that a perfect gas under such conditions kept its temperature constant. But the expanded gas is obviously in the same condition as if it had been used for elevating heat into work, and to get it back to the standard state, energy must be degraded into heat. It is, therefore, branded with the same entropy ϕ_1, or 0·2 of a claus, as before. Obviously, the entropy depends on the state of the substance, not on how it got into that state. Entropy can thus increase without the substance taking in any heat at all; but the entropy of a body cannot be decreased without giving out heat, and it can only give out heat at such a temperature that the entropy of the body receiving heat is increased at least as much as that of the substance is reduced, so that entropy, as a whole, can never diminish.

It might be said that as the expanded gas has to degrade high-grade energy into heat to get back to its original state, it might as well be branded not with the entropy but with the energy it must give out as heat in its return. But the amount of energy that has to be given out is indeterminate, while the entropy is definite. If the gas has to give out 0·2 claus, it is best to make it give it out at the lowest temperature possible, so that it corresponds with as little heat as possible; just as it is best to increase the entropy at the highest temperature, so that you take in as much heat as you can for a given increase in entropy of the gas.

If we imagine ideal conditions, so that there is no friction, no slope of temperature, &c., we can work with reversible cycles, and the entropy is always numerically equal to $\int dH/\theta$; on this basis we can work out all the ideas of reversible thermo-dynamics, and books full of differential equations have been written, connecting H, p, v, θ, &c., in every conceivable way.

But Clausius did more than this; he pointed out that any departure from reversibility involves increase of entropy. All degradation of higher energy into heat is obviously increase of entropy. Heat flowing from a hot to a colder body involves growth of entropy. Expansion of a gas into a vacuum, or diffusion of one inert into another inert gas, all chemical, and all other changes mean increase of entropy. Kelvin and Clausius thus discovered a master secret of Nature when they told us that entropy always increases. No change of any sort whatever can take place unless it involves increase of entropy. If the entropy would remain constant in a proposed change, there is equilibrium, and the change will not take place. If the entropy would diminish, the change is impossible.

We may now attempt to define entropy. Starting from a standard state as having zero entropy; entropy is numerically equal to the heat that would have to be given out if the substance could be brought to the standard state by a completely reversible process, divided by the temperature at which

the heat would be given out. Or, in mathematical language, the entropy is numerically equal to the value that $\int d\text{H}/\theta$ would have if a reversible change were possible from the standard to the state in question. Except that it is always greater than $\int d\text{H}/\theta$, the entropy has nothing to do with the heat absorbed during the actual change from the standard to the new state. Except that it is always less than the heat given out during actual return to the standard state divided by the temperature, the entropy has nothing to do with the heat given out.

For ease in mathematical work, thermo-dynamicians generally discuss reversible changes very fully, and often hardly touch upon real processes at all. It is generally easy to tell from the context when their statements are limited to reversible cases; but this practice has led to a very general misunderstanding of the meaning of entropy, and, as I have elsewhere pointed out, text-books on mathematical physics and on steam engines frequently state that entropy is $\int d\text{H}/\theta$, which gives a wholly false idea of the function. In the imaginary case of reversibility there is no increase of entropy. During any such change one body's entropy increases just as much as another's decreases. There is thus conservation of entropy. If entropy were conserved its differential would be exact. Unfortunately, mathematicians are often fond of using mathematical symbols without understanding their physical meaning. It is sometimes stated, for instance, that if a quantity depends on the co-ordinates its differential is exact. This is an error. If its differential is exact the quantity is a function of the co-ordinates, but the converse is not necessarily true. If a quantity is conservative its differential is exact. Lagrange introduced the principle of generalised co-ordinates in dynamics before the conservation of energy was understood. Energy is conservative, and its differential is therefore exact, so Lagrange's equations were applicable. But now that the conservation of energy is understood the whole question of Lagrange's co-ordinates might, I suggest, be made much simpler and more intelligible if the underlying physical basis were made plain at once. Prof. G. H. Bryan is not only a very able mathematician, but he is also an authority on advanced thermo-dynamics, so I will use him to point a moral. In discussing my Physical Society paper, Prof. Bryan smiled and pointed the finger of scorn at χ (the quantity factor of sensible heat, such that $\int \theta d\chi$ represents the increase of heat energy of a body), because, unlike $d\phi$, $d\chi$ is not, according to him, an exact differential, and therefore depends on the history of the working substance, and not on its actual state. Prof. Bryan here makes three blunders in one breath. First, he makes out that $d\phi$ is an exact differential, whereas it is only an exact differential in the purely hypothetical case of reversible change, and the paper he was discussing dealt essentially with real thermo-dynamics; second, $d\chi$ would be an exact differential in reversible changes, like $d\phi$; third, he infers that if $d\chi$ is not an exact differential, χ cannot be a function of the co-ordinates. This is blind mathematics, and shows that even eminent mathematicians and thermo-dynamicians work with symbols without understanding their real meaning. I feel sure Prof. Bryan will not mind being used as a horrible example.

The treatment of $\int d\text{H}/\theta$ in reversible processes became very important in developing the second law of thermo-dynamics, and the importance of the function entropy in nature, as always tending to increase, has been frequently overlooked.

Engineers and physicists are accustomed to look upon all energy as being unavoidably degraded down into heat, and this idea is so burned into most of us that many will hardly realise that that is only one way of increasing entropy. Friction, developing heat, produces entropy. As the heated bearing gives up its heat by conduction to the surrounding cooler bodies, there is increase of entropy. What I want to urge here is the advantage of the view that Nature always increases entropy, and the degradation of higher energy into heat is only one, though the commonest way of increasing the entropy of the universe. The inter-diffusion of two mutually inactive gases at constant pressure and temperature into each other produces no heat, and therefore no degradation of energy. It produces increase of entropy though, otherwise it would not take place; and to separate the gases and restore them to their original state demands degradation of higher grade energy into heat. It may be urged that the diffusion is thus the first step in the path of production of heat; quite so, but Nature is not a human being, and a process like diffusion must be considered by itself, and we have here, and also in the case of expansion into a vacuum, a process determined by the increase of entropy, and not by development of heat.

The importance of the Kelvin-Clausius dictum that "entropy always increases," is nowhere more clearly seen than in chemistry. For a long time the engineer's idea of production of heat reigned in chemistry. It was supposed that a chemical action was determined so as to evolve heat. This was Berthelot's and Thomsen's theory, and the fallacy still runs riot through chemical literature. When a reaction produced cold, it was considered unworthy to be called chemical, and was branded as a merely physical exception.

About a quarter of a century ago it was pointed out to chemists that the Clausius-Kelvin law applied to chemical reactions. Hortsmann, Rayleigh (I think), Gibbs, Massieu, and in a special way, Helmholtz, pointed this out almost at the same time. In order to see whether the entropy increases, we must consider not only the substance, but the surrounding objects, and we can then work out expressions which cover the ground by remaining unchanged in value, if there is no increase of entropy, on the whole, and we can transform these expressions into terms of the co-ordinates of the substance. Gibbs worked out three such expressions; Massieu worked out two, practically the same as two of Gibbs's; and Helmholtz worked out one of Gibbs's. As Gibbs worked out the whole three, we can call them Gibbs's functions. The functions are such that under the variations considered the differential is zero if the process is absolutely reversible; in other words, if there is no growth of entropy. They are just compact and mathematically convenient expressions for seeing whether a given change is possible, in equilibrium, or impossible, using increase of entropy as the criterion.* Unfortunately, though the differentials of these functions are easy to interpret physically, the integrals are not, and the nomenclature adopted is, I submit with diffidence, not good. Thus $\text{U} - \theta\phi$ is called the "free energy" of the substance; but there is no particular freedom about it, and the second term is not any part of the energy of the substance. The term "thermo-dynamic potential" for $\text{U} - \theta\phi$, and for $\text{U} - \theta\phi + pv$ is given owing to some fancied resemblance to potential in dynamics. That is mere unimportant detail, however; the real point is the fact that no change in the universe can take place unless it increases entropy; and that this is not only the key to the energetics of chemistry, it is a law of Nature which ranks in importance with that of gravitation.

Yet treatises on thermo-dynamics leave this great law neglected in the background, using $\int d\text{H}/\theta$ as if it were really synonymous with entropy, and as if its sole use were to prove the second law and spin differential equations. Careful reading and consideration will generally tell one when the author is considering only reversible changes; and when he deals with irreversible changes he generally explains the increase of entropy. But people like Prof. Perry, whom I may take as a specimen, because he has put himself prominently forward in that capacity, define entropy as $\int d\text{H}/\theta$ and $d\phi$ as an exact differential, which not only leads to hopeless confusion in dealing with real thermo-dynamics, but either contradicts or hides the great law of Nature developed by Clausius and Kelvin, that nothing changes without increase of entropy.

We may put the absurdity of the ordinary definition of entropy as equal to the heat taken in divided by the temperature in another rather fanciful way. Imagine we wished to discuss trade, and we wanted to find a defini-

* If the equation for $d\Delta$, the increase of what Clausius called the "uncompensated work" in terms of θ, ϕ, p, v, and any other energy ordinates, such as E, Q in electricity, &c., be set down, $d\Delta$ can then be converted into any number of partial differentials, each having some co-ordinates constant. Integrating by merely removing the d, various "thermo-dynamic potentials" are obtained, including Gibbs's Ψ, Φ, and Ξ with signs reversed, showing that the increase of the uncompensated work, which includes increase of entropy, means decrease of the particular thermo-dynamic potential applicable to the circumstances.

tion for selling price, and already understood cost price. An ordinary tradesman tries to make a profit on every transaction, but he often fails. But consider Nature as a trader who always makes a profit, and simply refuses to carry out any transaction without some profit, though the profit may be cut down to an almost inappreciable amount in some cases. A writer, for simplicity of treatment, might discuss transactions under the limiting and impossible case in which Nature would make no profit. In that case the transaction would be perfectly reversible, and the cost price and selling price would be the same. What would we think of writers who on this defined the selling price as the cost price, and ignored the profit altogether? Nature may be regarded as a trader who wants to make a profit in entropy, and will not carry out any transaction, however small, of whatever kind, unless she can make some entropy. The increase of entropy in an irreversible process, that is, the excess of ϕ over $\int d_H/\theta$, was called by Clausius the "uncompensated entropy." The term may not be very happy, but the uncompensated entropy of a body resulting from a change is Nature's profit. The compensated entropy may be said to be compensated by the loss of entropy of some outside body which supplied the heat, the rest, the uncompensated entropy, is clear profit to Nature.

We humans do not care about entropy; what we want is high-grade energy. We want to transmit the high-grade energy economically, and to raise low-grade into high-grade energy. In transmitting high-grade energy, Nature takes her toll of entropy by producing heat by friction, resistance, &c.; we try to reduce this profit as much as possible, because though it does not lessen our energy it degrades it to heat. When we turn heat into high-grade energy Nature cannot permit any reduction of entropy. If all the heat is converted into high-grade energy, a medium such as a gas must be used, and the entropy of the gas must be increased, so that there is a profit at that step. The entropy of the gas and condenser must be further increased on compressing the gas to its original state. As Nature wants entropy and we want to convert heat into high-grade energy, we convert heat at a high temperature into work, and give back the corresponding entropy, plus the necessary profit, at as low temperature as possible, so that we elevate as much heat as possible into work, while satisfying Nature's desire for entropy. The engineer may be defined as one who gets as far as possible what men want in changes of energy while giving Nature the increase of entropy she insists upon having. This is, of course, a fanciful illustration, not an analogy.

It may be said, and I dare say well said, that entropy is not easy to grasp, and does not seem to correspond with any other physical quantity. This may be largely the fault of my explanation, but I submit that the whole subject can be simplified, and I began a paper for the Physical Society, of which the first part was read. The Physical Society, no doubt under the advice of a referee, thought it best not to publish this first part; but the subject seems so important that I hope to be able eventually to finish the paper and publish it in some form.

This article probably contains slips, especially in questions of history and priority. I make no pretensions to historical accuracy, and have no time for verification or reference, as, unfortunately, this paper has to be written in as limited a time as possible, on short notice.

ELECTRO-METALLURGICAL PROBLEMS.—V.

By ALEC. A. BEADLE, A.I.E.E., F.C.S.

Aluminium.

Except for oxygen and silicon, aluminium is probably the most abundant metal in nature, constituting from 10 to 20 per cent. of all varieties of clay, which are simply double silicates of aluminium, magnesium, soda, potash, &c., kaolin, bole and other clays and china clay consisting of almost pure hydrous silicate of alumina. It constitutes, in fact, an essential ingredient of almost every rock; so far, however, it has been found impossible to economically reduce the silicate, and bauxite, a hydrated alumina, found in France, Ireland, and in the United States, together with cryolite, a double fluoride with sodium, found chiefly in Arksut-fiord, West Greenland, have been the only sources of the metal. The sulphates or alum-bearing minerals serve also as a source of the aluminium salts.

Glancing through the history of aluminium, we find that it was first reduced from fused chloride or from cryolite by means of potassium and sodium, the chloride being made from alumina; then by electrolysis of the double chloride and of cryolite, and finally by electrolysis of alumina dissolved in fused cryolite; so we see that bauxite and cryolite have been the only minerals so far used. The whole of the aluminium of the world is now made by electrical methods, the principles of which are represented by the more modern processes of Cowles, who reduces alumina along with copper in an electric furnace forming an alloy; of Herault who reduces fused alumina with a carbon anode, and an aluminium cathode, CO_2 being evolved at the anode; and of Hall whose process is similar, but the alumina is dissolved in fused cryolite.

Modern practice has shown that the most satisfactory method of keeping the electrolyte fused is by means of the current itself, and, moreover, it is found necessary to use a cathode of molten aluminium and not of carbon or any other metal. The yield of metal is about 1 lb. per 12 E.H.P.-hours, which at $\frac{1}{4}$d. per unit represents about 3d.; this is, however, only a small item in the cost of production, the chief item being the preparation of pure alumina from the crude bauxite, which amounts to over 40 per cent. of the total cost of manufacture.

Crude bauxite contains iron, silicon, titanium and several other impurities which must be got rid of, and the methods of producing pure alumina are numerous, but depend for the most part on the precipitation of the hydroxide from alkaline aluminates into which the bauxite is first converted. Any slight impurities left are brought down during electrolysis with the first aluminium, except titanium, which causes trouble. However, modern pure aluminium contains up to 99·8 per cent., or even more of the metal, the impurities being chiefly combined and graphitoidal silicon and iron.

It would considerably cheapen its production if the metal could be first reduced from crude bauxite and then purified, and for this purpose many suggestions have been made, but on account of its extreme electro-positive nature, aluminium cannot be purified either by replacement or by subsequent electrolysis, and there seem to remain but few ways out of the difficulty, except to produce the pure metal in the first instance.

There seems to be some doubt as to whether alumina can be reduced to metal by any other means than by electricity. The combining energy of aluminium with oxygen is very great, exceeded only by that of magnesium. Winkler, however, has only succeeded in forming the supposed black suboxide by heating alumina with magnesium in a current of hydrogen. Borchers has practically proved that the heat of the electric furnace, apart from any electrolytic action, can reduce aluminium in presence of carbon; but this, in the author's opinion, requires further corroboration. Tucker and Moody claim to have reduced it with calcium carbide. The many attempts to reduce it by hydro-carbons, either alone or in cryolite, seem to have failed.

Much attention has lately been paid to the production of aluminium sulphide on account of its excellent adaptability to subsequent reduction, either with metallic iron or by electrolysis. The best known method for its production is that in which carbon disulphide is allowed to react with alumina at a high temperature, but this reaction is very incomplete. Blackmore first dissolves his alumina in a bath of fused alkali fluorides and sulphides, by which he converts all the alumina into sulphide. Bucherer heats a mixture of alumina, alkali sulphide, sulphur and coal, by which he obtains aluminium sulphide. These, and many other processes, start with pure alumina, and end with a mixture containing the sulphide; but what is required is to start with the crude ore, and end with the pure single, or better still, double sulphide. Aluminium sulphide fuses easily, and

when electrolysed at a moderate temperature with carbon anode and aluminium cathode, gives up its metal and evolves sulphur, requiring only about 1 volt for decomposition, and since the temperature required is not so high as with cryolite, the total amount of energy would be far less than at present.

Despite many statements to the contrary, there is no doubt that aluminium has never been reduced from solution, and in all probability, in this respect, it bears a close relationship to sodium; attempts in this direction are therefore but waste of time and money.

The applications of aluminium are daily growing, and will do so more rapidly as its price is lowered. The soldering of the metal is, in the author's opinion, not an impossibility, one solder bearing an approximation to perfection having come under his notice.

The use of aluminium in the form of extremely fine powder is rapidly growing; it was first used in the reduction of oxides and production of locally high temperatures in Goldschmidt's "Thermit" process, and for this it is contended that the metal need not be pure, a great advantage in its manufacture. According to *Mineral Industries*, a French firm undertook to supply 90 per cent. aluminium for this process at 2 francs per kgm.

Pure aluminium powder is proving a most valuable pigment for "aluminising" the ironwork of ships; it is mixed with varnish, and thus successfully withstands the action of sea water. In aluminium required for shipbuilding the addition of a small quantity of copper—up to 4 per cent.—seems to enable it to withstand corrosive action better, and one might reasonably suppose that if an impure aluminium were made from bauxite containing impurities electro-positive to copper, these might be replaced by that metal in a fused electrolyte containing it.

Magnesium.

Very much the same remarks apply to the very general occurrence of magnesium silicates in nature as to aluminium. It is, however, found in comparatively large quantities in the more convenient forms of soluble chlorides and double chlorides (as carnallite, &c.) and sulphates (epsomite, &c.), and as single and double carbonates (magnesite, &c.).

Magnesium has a very great affinity for oxygen, hence magnesia has to be brought to such a high temperature in contact with carbon that the metal is volatilised, and the difficulties in its condensation and melting are great, as it so rapidly re-oxidises.

It is practically certain that, like aluminium, magnesium cannot be reduced from aqueous solution except into a mercury cathode, and consequently there remains but one method for its reduction, and that is either to electrolyse or reduce by sodium the fused haloid salt.

For this purpose carnallite, either natural or artificial, being a double chloride of magnesium and potassium, is eminently suited; it gives off nearly the whole of its water of crystallisation and fuses down to a clear liquid at a temperature below 700° C., from which the magnesium can be reduced.

The electric current liberates chlorine and metallic magnesium, which floats and must be kept away from both chlorine and air. This is generally accomplished by passing an inert gas through the chamber containing the magnesium. The cathode current density need not exceed 1 ampere per square inch.

The cheapening of magnesium is more a matter of constructing reducing apparatus that will not rapidly deteriorate, than of anything else; but perhaps its limited applications have not brought the problems of its economic production forward so much as those of other metals, although, no doubt, if it could be produced considerably cheaper, its use as a reducing, dehydrating, and illuminating agent would be greatly increased. An alloy of aluminium containing about 10 per cent of magnesium, and called "magnalium," is proving very useful. It is almost like silver in appearance, having high reflective power, can be cast, turned, and fine threads cut upon it. It will also take the file better than aluminium alone, and is, moreover, said to resist air and water well; but to fulfil all these conditions it must, of course, be quite free from sodium.

Sodium.

The "ores" of sodium are too well known to need description, as are also the secondary products obtained from salt. The value of the sodium contained in all of these in the combined state is such that if only it could be easily reduced, the margin of profit would be very great. The present price of metallic sodium, however, prohibits its uses in many directions, but as a reducing agent the demand would rapidly grow as its price became lower, so that eventually it might be possible to use the metal as a source of pure caustic soda, when the demand would be practically unlimited. In this direction this ideal has, to some extent, been realised, as in the Castner-Kellner alkali process, in which the sodium is deposited into mercury, and from this into water, as well as in the Vautin fused lead process. Sodium in a free metallic form is, however, here never made, neither can these processes be regarded as a step in this direction.

The history of the production of metallic sodium is closely connected with that of aluminium, and has been full of changes. In later years the metal was condensed from retorts in which a mixture of sodium hydroxide, iron and charcoal were heated together, and finally, by the now well-known Castner process, in which the hydroxide is heated in iron crucibles to a temperature only just above its melting point, and electrolysed with iron electrodes. In this way sodium is liberated along with hydrogen at the cathode, and oxygen at the anode. The sodium thus produced is worth £200 per ton.

In the Darling process this principle is modified by a porous diaphragm using fused nitre round the iron anode. NO_2 is evolved and converted into nitric acid, but the whole process hinges upon this very questionable anode.

It takes nearly two tons of caustic soda (value £20) to produce one ton of sodium, so that there is ample room for great improvement in the present expensive methods of production; and the attention of chemists has, therefore, been turned to one of the very first methods used in its production, the electrolysis of fused chloride of sodium. The chief and most obvious difficulties in this direction lie in the construction of the apparatus, so that the patents and suggestions put forward have been remarkably numerous; but there are equally important chemical and electrical difficulties which are not so generally understood, and, although none seem absolutely insurmountable, the general prospect cannot be said to be a promising one.

It is a curious fact, however, that so many experimenters have paid little or no attention to the purity of their salt, but have assumed it to contain nothing but sodium chloride, a circumstance practically unknown. These processes have been based on several ideas. The original one was to electrolyse a fused bath of salt, producing chlorine and sodium vapour, which was to be condensed, but, owing to the close proximity of the volatilising points of the chloride and the metal to each other (about 900° C.), both products distilled together. The second was to reduce the metal in a molten condition from a mixture of alkali-chlorides having a much lower fusing point than salt alone; if comparatively electro-positive metals are chosen, the resultant sodium is fairly pure.

Neither of these ideas has ever been brought to a practical issue; the second is the most promising, but it is doubtful whether either process will ever prove commercially successful, The difficulties of manipulation make either almost an art, but they may be overcome in time. The sodium which is liberated has about half the specific gravity of the melt, and floats about half out of it; the chlorine which is liberated, being free from carbonic acid, is well suited to the manufacture of bleach, but would probably have to be cooled and moistened before passing over the lime. Carbon anodes withstand the action of the salt admirably, but as cathodes carbon is rapidly corroded and swells up into a kind of carbide; iron, however, can be used for this purpose.

Three actively-corrosive materials have to be dealt with, chlorine, salts and sodium all at a red heat; the first a powerful oxidiser; the second capable of dissolving almost any fire-clay or ordinary metal; and the third a powerful reducing agent, acting on any non-conducting body.

The most essential factors in the cost of sodium thus produced are energy, which at, say, ¼d. per B.T.U., would theoretically be less than 1½d. per lb. of metal, the salt

which hardly counts at all, and the fuel for maintaining the requisite temperature.

If this heat be supplied by a higher current and voltage, say, by doubling the watt-hours per pound of metal produced, many difficulties disappear in the construction of the apparatus. The chlorine being a useful bye-product also aids the process, so that it is evident that this problem deserves much consideration.

THE LOCAL GOVERNMENT BOARD AND THE BOROUGH OF HACKNEY.

What powers do the Local Government Board possess in controlling the expenditure of municipalities?

This question is very much in evidence just now in the Borough of Hackney—where the state of the accounts has caused considerable commotion among the ratepayers. The District Auditor appointed by the Local Government Board, issued a report on July 7th last, and his statements naturally caused no little anxiety and indignation in the Borough.

He speaks of the "incomplete and unbalanced condition of the accounts when first presented for audit, and which showed an aggregate deficiency of £10,479 10s. 9d.," and he goes on to say :—

I found, however, that this was far from being a true statement of the case, that the position was, in fact, very much worse, and that corrections were necessary in regard to the following matters: —

1. An unauthorised loan of £10,000 had been raised in 1898 or 1899, by the late vestry, and a transfer of £5,000 had also been made from the monies deposited with the Council to defray the cost of making-up new streets; expenditure which should have been borne by the rate funds, had been defrayed by the £15,000, thus borrowed without sanction, and items of this expenditure amounting to £5,500 were still shown as balances to be borne by future years.

These balances have now all been charged to the General Fund, and the unauthorised borrowings have been discharged.

2. Some further expenditure in excess of sanctioned loans was also carried forward on the balance sheet and had to be charged to the General Fund.

3. The interest upon the electricity loans from March, 1899, to March 31st, 1901, amounting to £2,801 4s. 8d., had also to be charged to the capital funds. It was entered in the accounts amongst the items of expenditure to be borne by the loans.

He further points out that an asset of £3,400 appeared twice upon the balance sheet—that a School Board precept for £16,257 had not been taken account of—and adds that these corrections brought out an aggregate deficiency in the rate funds of over £40,000, or taking account of arrears of rates, reduced it to £29,235 19s. 4d. Another deficiency alluded to by the auditor is £2,459 18s. 5d. on new streets account.

This extraordinary state of affairs very naturally led to a demand for an official inquiry; and a letter to the Local Government Board from the Hackney Ratepayers' Organising Committee, dated the 22nd ult., refers to the disappointment experienced by a large body of memorialists at the reply of the Department intimating that they had no power to direct an inquiry.

The case does not rest merely upon the auditor's report, but according to the letter referred to, other matters would have been submitted for investigation, the allegations, whether based upon mere rumour or not, proving how necessary it is for a thorough and impartial investigation into such charges as—

The alleged loss or destruction of a number of rate collecting and other books; the withholding of information by the Finance Committee from the Council; the dismissal of certain officers by a very narrow majority, in face of the protest of a considerable minority of the Borough Council that these men had not been heard in their own defence; the appointment of temporary officers to permanent positions on the staff, under circumstances and through influences demanding a searching inquiry, and the financial obligations of certain officials to subordinates, a condition of things inimical to proper discipline.

There appears to be some attempt to screen the present Borough Council by throwing the blame for all these irregularities upon the late Vestry; but, as a matter of fact, the majority of the new Council were members of the old Vestry, merely changing their designations from Vestrymen to those of Aldermen and Councillors. Out of 69, no fewer than 37 were on the old Vestry.

The electric lighting undertaking has started with a very heavy loss, and in order to allay the growing apprehensions of the ratepayers, the Lighting Committee have hurriedly issued a statement which attempts to show the result of the trading for 11 months, an odd but significant course to adopt, as a delay of a few weeks would have enabled the Committee to prepare accounts for a completed year.

The statement sent out is altogether misleading, alleging a loss of only £73 by ignoring a large amount for interest, sinking fund, depreciation, and other liabilities. In fact, a very thorough audit of these accounts ought to be insisted upon, to enable the ratepayers to fully understand the result of Hackney's costly experiment in municipal trading.

Further heavy outlay is contemplated, and it is intended to apply to the London County Council for a further loan, which will avoid the necessity for any action by the Local Government Board. The Committee suggest an approach to the consulting engineer for some reduction in his commission on this fresh expenditure, and as they allege that he has received 5 per cent. upon £300,000—say £15,000—it is not surprising to learn that he was open to an arrangement.

The 11 months' accounts to September 30th, 1902, show a capital expenditure of £207,722, a total revenue of £11,606; working expenses (exclusive of carbons and maintenance charges of public lighting) of £4,969, leaving a gross profit of £6,637, against which interest and repayment of capital are stated to amount to £6,710, leaving a deficit of £73.

Starting with this sum of	£73
the following additions must be made to the actual loss upon the 11 months' trading :—	
Interest, mentioned in the auditor's report as having improperly been charged to capital	2,801
Five months' interest not charged in the account for the 11 months' trading, say	4,171
Depreciation on, say, £200,000 at 3 per cent. per annum, for 11 months	5,500
(Sinking fund from March, 1899, to September 30th, 1902, at 2½ per cent., say, £17,500, of which only £1,104 repayment of capital is charged. The repayment of capital is deferred for three years, but this concession to the borrowers does not release them from the liability, in considering the result of the trading.)	
Cost of carbons and maintenance on 293 arc lamps for 11 months	750
Actual loss, exclusive of sinking fund	£13,295

This calculation is much nearer the correct position of the undertaking than the absurd figure of £73, to which the borough electrical engineer has affixed his signature.

But there are other matters to be considered in dealing with these accounts, such, for example, as the charge for public lighting at the rate of £20 per lamp per annum. The cost of running these lamps should not exceed £15 per annum, including all charges and interest on capital, consequently £5 per lamp, or, say, £1,000 profit to the electric lighting undertaking is being paid by the ratepayers through another Committee, the money being taken out of one pocket to put it into another.

If a thorough audit and official inquiry were made, it would dispose of other rumours in the Borough, dealing with the rates and taxes paid by the electric undertaking, the clerical assistance of the town clerk's and surveyor's departments, and labour charged to the General Purposes Committee.

Surely, sufficient evidence is apparent for justifying the searching inquiry demanded by the ratepayers, and if the Local Government Board has no power to undertake it, the position of that department, which was organised under the Act of 1871 to deal with the local authorities, is a very anomalous one. To have the control of the borrowing, to appoint the auditor, and, not to be able to inquire into the accounts which he finds to be in an unsatisfactory condition, is a *reductio ad absurdum*.

As to the electrical undertaking, the best course for the ratepayers would be to get clear of the speculation if a reasonable chance of doing so should present itself. Alderman Wells-Holland, at a meeting of the Hackney Borough Council on the 18th ult., said: "They knew perfectly well there was an offer of more than £300,000 for the undertaking." If this be true, the sooner a sale is effected the better for the ratepayers—for the prospects of success as a municipal undertaking are very remote.

THE USE OF BLAST FURNACE GAS IN GAS ENGINES.

IN continuation of our review of the paper and correspondence upon the subject of our heading, given by Mr. Cecil A. Cochrane before the Cleveland Institution of Engineers, we will summarise the letters from correspondents in *Engineering*. Mr. B. H. Thwaite points out that Mr. Cochrane does scant justice to other pioneers in the application of blast furnace gas in this country, and claims that the credit belongs to Mr. Jackson of the Clay Cross Ironworks, for gas-driven blowing engines; and to the Sheepbridge Coal and Iron Co. for utilising the new power for electric traction and lighting; while he remarks that the work done in bringing the gas engine up to the position it holds to-day by the firm of Messrs. Crossley Brothers, Ltd., is entirely overlooked.

Mr. W. E. Philbrow had quite a long letter in the issue of December 26th, dealing with points which formed the subject of an editorial article. After complaining that our leading men take careful note of advances made on the Continent and in the States, while almost ignoring any progress by their compatriots, he goes on to suggest that the editors of the leading technical journals are not above that reproach. He gives credit to M. Greiner for having boldly struck out, when the opportunity offered, and built a gas engine far exceeding anything then existing, but he says that it was a Britisher who developed the necessary apparatus for properly cleaning even the dirtiest gas, and that even M. Greiner had adopted a modification of the Thwaite system, as well as several large installations on the Continent. He disputes the idea "that we are now dependent on them [foreign engineers] for the designs of these engines," and complains of mis-statements made by such an authority as *Engineering* as being injurious to this country's industries.

The writer goes on to take exception to such a high mean pressure as 90 lbs. per square inch being obtained from such poor gas as Cleveland blast-furnace gas, as from an examination of cards from various engines on the Continent and in Britain the highest mean pressure obtained is only about 70 lbs. per square inch, and there follows an illustrated criticism on the indicator cards which accompanied the editorial article in the columns of our contemporary. The concluding sentence may be quoted:—"The question comes to one's mind of how long a tube and how many stoves would be necessary to deal with 6,000 H.P. instead of only 600 H.P."

The same issue of our contemporary had a letter from Mr. T. J. Denny, of the Blast Furnace Power Syndicate, Ltd., on the subject of Mr. Cochrane's paper, in which he says that the chief merit of the paper is the fact that the author has been good enough to unreservedly give the results of the experiments and details of the apparatus employed.

He goes on to remark that the author makes it clear that the proper treatment of blast-furnace gas for use in gas engines was very little understood by his firm or his advisers, as is shown by the twelvemonth's experimentation.

In regard to the gas engine *per se*, he says, that this has been so far developed that there is little need for further experiments, as good working results are readily guaranteed by the best makers, so his remarks will chiefly be confined to the treatment of the gas.

The writer of the letter, after referring to the fact that the gas *must* be cooled, takes exception to the apparatus adopted for this purpose in this instance, and we give the remainder of the letter in his own words:—

> The cost of tubing 5 ft. 6 in. in diameter, and of considerable length, along with the cost of a stove-casing, when added to the fans, and apparatus for driving these, and the coke scrubbers, will compare very badly with our so-called static installations, which have been adopted in this country and in Germany, and which Mr. Cochrane admits give perfect results.
>
> The adoption of such a cooling apparatus as a tube 5 ft. 6 in. in diameter and of great length, associated with fans supplied with large volumes of water and motive power for driving the fans, hardly appears to be a scientific attempt to purify the gas. . . .
>
> The cost of the new tubing and stove casing would, we calculate, not be less than £3,000; with fans and motors, say, £3,320, or £5 10s. per H.P.
>
> With the dynamic system of cleaning, even when assisted by the apparatus described, unless the speed of the fan and a certain volume of water are maintained, the results, Mr. Cochrane says, are disastrous. Whereas in the static or Thwaite method no such critical condition exists, and only men of the labouring class are required to attend to the apparatus.
>
> After Mr. Cochrane's statement that, having no gasholder at Ormesby, he was unable to state the consumption of gas, how has the consumption given in the test of the 600 H.P. engine made at Ormesby, December, 1902, been arrived at?
>
> Again, how does he reconcile his statement that "We never had any hesitation in adopting the 'dynamic' method of cleansing" with the application of a long tube of large diameter and a converted stove-casing?
>
> If one-fifth of a mile of tubing, 5 ft. 6 in. in diameter, and a stove-casing especially prepared, along with two fans and motors of 26 H.P. are required for each 600 H.P. gas engine installed, no doubt ironmasters will hesitate to adopt any such system. Compared with the static system, the ground-floor space occupied is twice that required for cleaning 300,000 cb. ft. per hour by the latter method, or a ratio of 10 to 1. . . .
>
> By the static method gas engines can be kept running continuously for long periods, as the dust-removal apparatus can be cleaned in sections without necessitating any stoppage, and the water condensation from the gases goes far towards providing the necessary liquid agents for washing the gas in the box washer and the centrifugal fan. Moreover, the proportion of the motive power required is a small ratio of that required in the dynamic system.

Mr. Cochrane's paper drew a letter from Mr. W. J. Crossley on behalf of Messrs. Crossley Bros., Ltd., to the effect that, being makers of over 40,000 gas engines, they can hardly be forgotten, and goes on to say that his firm, like Messrs. Cochrane & Co., were led to believe by M. Greiner's paper that there was no necessity to make any special preparation for the treatment of blast furnance gases; they now readily confess that treatment to remove dust before the gas comes to the centrifugal separator is quite needful, quoting Mr. Cochrane's paper as proof.

He concludes his letter by saying that his firm will be glad to use the Thwaite system where possible.

The general conclusions to be drawn from Mr. Cochrane's paper and the correspondence are, that for such gas as that issuing from the Cleveland furnaces, special apparatus is required for removing the dust over and above the *dynamic* apparatus which the firm first decided to adopt, and that though the apparatus adopted in this instance was to a certain extent satisfactory, it would hardly recommend itself to ironmasters not so favourably situated in regard to spare stove casings, &c., while specially designed apparatus exists for washing, cooling and scrubbing, which gives results rendering the gas, produced as it is in such large volumes, perfectly suitable for use in gas engines, without necessitating excessive lubrication, or allowing of troubles from accumulations of dust in the gas engine cylinder.

CORRESPONDENCE.

Electrolytic Meters.

In asking you to kindly afford us an opportunity of replying to the statements made regarding the Bastian meter by Messrs. Chamberlain & Hookham, Ltd., in your current issue, we desire, at the same time, to disclaim any interest, direct or indirect, in the authorship of the article, the terms of which have apparently provoked their surprise.

That Bastian meters are accurate to within 1 per cent.—that is, for all practical purposes, dead accurate—is not in any way a debatable statement, but a statement of fact that can be fully substantiated, and to argue otherwise, it would have to be admitted that the laws of electrolysis are not to be relied upon. This would be as absurd as Messrs. Chamberlain & Hookham's statement that the Hookham meter consumes half a volt and uses no current.

Your correspondents also say that the accuracy of our meter depends upon the condition of the chemicals used; but this is a mis-statement, as the accuracy is just the same whether filled with ordinary tap water, or with water plus *any* proportion of commercial sulphuric acid or commercial caustic soda. In fact, we maintain that the purity of the mercury in a Hookham meter is of more importance than the purity of the chemicals we use, though we are aware that only commercially pure mercury is considered necessary.

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As we are concerned in refuting mis-statements of fact, we will pass over mere irresponsible insinuations against the Bastian meter, as we should expect to be passed over any similar insinuations regarding the messiness of mercury or the uncertain operation of motor-meters in general; one can hardly expect the mouse to hold forth on the good qualities in the character of the cat.

Damaging mis-statements, however, compel us to say that Bastian meters have been known to the trade for five years, and most of the first hundred ever made are still in constant use at Holbein House, Chelsea, where they have been since the commencement of 1897, and nearly 12,000 have since been sold.

Messrs. Chamberlain & Hookham's statement, that electrolytic meters cannot be tested for accuracy by easy and effective means, does not apply to the Bastian meter, which can be accurately tested in less than five minutes *without current* over the full range of the recording scale, with the aid of a simple standard liquid measure, whereas a motor meter can only be tested *in circuit* with the assistance of a watch and accurate ammeter, and should it be desired to test it on the recording dials, the operation will take several days. It has therefore become the custom to test motor-meters on the driving spindle only, taking for granted that the intermediate gearing between the spindle and the recording dials is accurate, and this, in many cases, has led to serious error.

The remarks about the early forms of electrolytic meters having proved unsatisfactory, only apply to those of the *shunted type*, in which inaccuracies may occur that are not possible in the case of an unshunted meter like the Bastian meter, through the electrolytic cell of which is passed the whole current to be measured.

Certain motor-meters have also proved failures in the past, but it would be weak indeed to raise that as an objection against the more perfect instruments now to be obtained.

Both types have their advantages and their disadvantages, and their respective fields of usefulness, and business in them can be obtained by fair competition, and without the aid of such unwarrantable and irresponsible attacks as that made on us by Messrs. Chamberlain and Hookham, Ltd.

Apologising for the length of this letter,

The Bastian Meter Co., Ltd.
Chas. O. Bastian, *Managing Director.*

I have read with much interest Messrs. Chamberlain and Hookham's letter in your last issue. There is, however, one point that appears to me to be misleading, viz., "that the amount of water decomposed in an electrolytic cell depends upon the chemicals used." Any first-year's student could tell them that the water only is decomposed, and that this is in strict proportion to the current passing through. Their remark, therefore, is as much to the point as for anyone else to say that the accuracy of a Chamberlain & Hookham meter depends upon mercury, and not treacle, being placed in the retaining chamber.

Herbert C. Hodges.

Watford, *January 5th*, 1903.

We are glad of an opportunity of refuting some of the statements which, as your Birmingham correspondents truly say, go a little beyond mere trade appreciation. The absurd claims which are often made in favour of electrolytic meters would lead anyone not practically acquainted with the business to the belief that electrolytic meters are simply infallible as regards light load accuracy.

As regards first cost and light load accuracy, we wish to emphatically state that motor-meters of 5 amperes capacity and over can be bought for less than the 50s. stated as a minimum figure by your contributor, and are more than equal to any electrolytic meters as regards continued light load accuracy and length of life; moreover, we ourselves are not the sole makers of such meters.

Again, the shunt loss is urged as a sufficient reason against the use of motor-meters for small consumers, but surely your contributor is aware of the existence of motor ampere-hour meters, which have no shunt windings, and therefore no shunt loss; in fact, ampere-hour meters are almost universally used for direct current circuits. The question of voltage drop in electrolytic meters is much more important, as it occurs most seriously at the time of heaviest load on the station.

Prepayment meters such as suggested by your contributor, in which the meter in the coal cellar is electrically controlled by a prepayment attachment in the hall, would fail in the very first essential of such apparatus, viz., cheapness. We venture to predict that the future prepayment meter will be a self-contained mechanical apparatus, which contains neither glass nor chemical solutions.

The Electrical Co., Ltd.
J. Stottner.

London, *January 5th*, 1903.

Entropy.

As Prof. Perry's letter appeared in your columns, perhaps I ought to answer it. I have already tried to do so in the *Electrician* of January 2nd, or rather I have amplified the statements in the note in my address. Beyond some groundless accusations to the effect that I denied the second law of thermo-dynamics, and held that entropy is not a function of the state of a substance, there is nothing to answer in his letter. Prof. Perry merely repeats the conventional statements I originally criticised, and even emphatic repetition of a disputed proposition, is not useful discussion. In consequence of the attitude he has adopted, I feel justified in referring specifically to any errors he may have committed in thermo-dynamics, and in so far as such errors are typical of those I condemn, I feel sure Prof. Perry will not mind my making use of them as definite instances. My original criticisms were not in any way directed against Prof. Perry in particular. Saving that as far as I know it at all, his book on the steam engine seems particularly good, it is in no way exceptional. It appears to contain the wrong idea of entropy of which I complain, certainly, but it is not in any way peculiar in that particular. I do not know even yet whether he considers entropy a factor of heat, though I noticed he used Q, which generally denotes a quantity factor, in his equation, $d\text{H}/\theta = d\text{Q}$. I have little doubt Prof. Perry will give his reasons in due course for his definition and other statements.

James Swinburne.

41, Palace Court, W.
January 5th, 1903.

Wireless Telegraphy in Jamaica.

In your issue of November 28th, p. 909, I see a paragraph to the effect that the local government here is to introduce a Bill during the next session of the L.C. to grant facilities for the establishment of wireless telegraphy in the Colony.

This is a trifle inaccurate; the facts of the case being that a Bill is to be introduced empowering the Governor in Privy Council to deal with applications to erect and work wireless telegraph apparatus in the Colony, which puts another complexion on the matter.

Geo. A. Rock,
Superintendent.

Direct West Indies Cable Co.,
Kingston, Jamaica,
December 22nd, 1902.

The Sugden Boiler.

Referring to the letter from Mr. J. C. Stewart, which appeared in your issue of the 2nd inst. respecting the Sugden boiler, one or two points are raised which call for explanation.

As regards superheating, the illustration in your issue of the 19th ult. shows a superheater fitted to the boiler; this, however, is an accessory, and is only supplied as such. If a superheater is not required, the stop valve is placed on the steam receiver in accordance with usual practice. The method referred to by your correspondent of placing a super-

heater on alternate boilers is sometimes adopted in installations where a high degree of superheat is not required.

With respect to enlarging the area of the header connections with the steam drum so as to equal the combined area of the water tubes, this, as you point out in your editorial note, would make a cumbersome connection. Within certain limits the restricted outlet does not unduly retard circulation. The point raised, however, is a very important one, and indicates the serious disadvantage of adopting long headers having numerous tubes, which, while making a cheap boiler, results in defective circulation and its consequent evils.

It may be observed, given the same length and section of header, and the same number of tubes, that a straight header will admit of much greater freedom as regards circulation than can be obtained through the tortuous course of a staggered header.

T. Sugden.

180, Fleet Street, E.C.

Speedy Tramcar Erection.

What is the largest number of tramcars completed in a given time?

The speediest piece of work I have been on was at Bristol, where our gang erected and painted trucks, mounted 270 motors, removed all wheels and axles to test truth of wheels, and replaced over 100 wheels by new ones; fitted slipper brakes; mounted car bodies of 135 cars in exactly three months (July to October, 1900)—an average of 10½ cars each week during 13 consecutive weeks.

The speediest part of that work was receiving 50 controllers one Saturday afternoon, mounting them, and connecting up cables, and putting 25 cars into service trials within 40 hours.

I have worked for other firms since, but never turned out more in the same time. Mr. Heppell was in charge of this car work, and if he sees this he will confirm my statements.

J. William Smith.

Gloucester, *January 2nd*, 1903.

ELECTRICITY ON TRUNK LINES.

THE New York *Electrical World*, in a recent editorial, discussed an article contributed by Cornelius Vanderbilt to the *North American Review*. It was a study of the above subject from the standpoint of the railway manager. It must be remembered that, aside from his official status, Mr. Vanderbilt is an engineer whose opinion must command respect. In this case his views are singularly conservative and sane, and while the electrical engineer may find some items for criticism, he will, in the main, agree that the conclusions are sound. Roughly to summarise the points of the paper, Mr. Vanderbilt divides the total expense as follows:—Cost of unit weight of fuel, useful work realised per unit, cost of handling trains, cost of repairs to machinery, cost of repairs to roadbed. As to the first item, he finds approximate equality for electric and steam operation, save in isolated cases where low grade fuel of water power can be economically used for the electric stations. In work realised per unit of fuel, the result is nearly a stand-off with perhaps a slight advantage in favour of electricity. Cost of handling trains should not vary with the motive power, since no hands could be dispensed with safely in electrical driving. As to repairs on machinery, the larger total amount in electrical equipment would offset, or more than offset, any intrinsic gain in favour of the motors, and in repairs to roadbed. Appearances indicate little difference, although the third rail, if used, would be an additional item of maintenance. When it comes to the cost of equipment Mr. Vanderbilt considers that on the two systems the cost of rolling stock, including motors and locomotives, would be about the same, leaving the electric generating and distributing systems as additional items of expense which must justify their existence by increasing the power delivered per unit cost of fuel. The possibility of doing this is held, very properly, to depend on the density of traffic on the road, which Mr. Vanderbilt considers to be very rarely great enough on trunk lines, if ever, to give electric operation the advantage.

Mr. Vanderbilt fully recognises the advantages that may be gained in handling a dense passenger traffic by electric trains, but he is here discussing the desirability of electric traction in the general service of "trunk lines." In this paper he has put his finger with unerring instinct on the weak point of electric traction on a large scale, viz., the losses and expense in the transmitting and distributing system when dealing with traffic of small or moderate density. He falls into the error common among those who are not practically familiar with electric power transmission of somewhat overestimating the losses in the line, and thus exaggerates one factor in his estimates, but not by an amount which at the present time vitiates his conclusions. The loss from prime mover to driving-wheel is indeed the most serious obstacle to electric traction on a large scale. When traffic is very dense, this loss is relatively of much less importance than elsewhere, and may be far outweighed by the undoubted advantages of electric driving, but it is certain that this loss is one which engineers should strive assiduously to reduce. The major part of it, however, generally lies between the step-down transformers and the driving-wheels, rather than on the side towards the prime mover. All the recent experiments have been directed to the reduction of this fraction of the loss, either by the use of alternating motors, polyphase and other, or by employing rotary converters or motor-generators on the locomotives, thus doing away with the extensive low-tension distributing system. Obviously this procedure is not merely an extension of ordinary trolley practice, but a direct attack along a new line on the more serious problems of the art.

As Mr. Vanderbilt very properly points out, trunk line conditions are not to be properly met by a mere extension of ordinary trolley lines, and the more fully this fact is understood, the better for electric traction in general. As we have many times pointed out, there is a large class of interurban roads which must, in many of their relations, be classed with ordinary railroads, and yet there is a very wide distinction between even these and the big trunk lines which derive, and must continue to derive, a very large proportion of their revenue from hauling the country's freight. There is every reason to believe that electric traction will steadily increase, and that it will yearly assume a more serious position in general railroad work, but this is far from asserting that the locomotive will soon be a back number. And there is good reason to believe that the locomotive is capable itself of very considerable improvements. As a result of the Zossen tests, a determined effort is being made to produce a locomotive especially suited to very high speeds, and the results will throw considerable light on the improvements that may fairly be expected.

THE PRICE AND METHODS OF CHARGING FOR ELECTRICITY.

BY A LEGAL CONTRIBUTOR.

ONE of the most important branches of the law relating to electricity is that which deals with and prescribes the method whereby the supply company shall charge the consumer for current. With the constant improvement in the methods of supply, and the important discoveries which yearly lead to more economical methods of producing and transmitting electricity, undertakers often find it necessary to apply to the local authority or the Board of Trade for power to vary the terms of their original contracts with consumers. It may become expedient to effect a considerable change in the pressure of the current supplied. To double the voltage of electricity may be economy of the highest order, but it must render useless a large number of incandescent lamps belonging to consumers. Who, then, is to defray the cost of providing new lamps?

Again, the supply company may consider it desirable to change over from the continuous to the alternating-current system. An alternating current cannot, as a general rule, be used for motive purposes. Who is to compensate the consumer for having to shut down his motor-driven mill, or who will defray the cost of exchanging continuous-current motors for machines which will co-ordinate with, and be capable of being worked by, the alternating current of the street mains?

One other aspect of the case presents itself. The undertakers may desire to vary the terms upon which they supply their current to the public. The price of coal, the price of labour, and many other agencies operate to render the economic price of electricity a fluctuating quantity. Regulations must therefore be provided whereby the price may be varied from time to time.

It is necessary to see how far the Electric Lighting Acts have provided answers to the foregoing questions.

Those parts of the Electric Lighting Acts to which reference should be made are as follows:—It is enacted by Sec. 19 of the Act of 1882 that, where a supply of electricity is provided in any part of an area for private purposes, then, except in so far as is otherwise provided by the terms of the licence, order or special Act authorising such supply, every company or person within that part of the area shall, on application, be entitled to a supply on the same terms on which any other company or person in such part of the area is entitled in similar circumstances to a corresponding supply. This section, which follows the precedent of the Gasworks Clauses Act, 1871, Sec. 11, and the Waterworks Clauses Act, 1847, Sec. 53, makes the supplying of electricity practically compulsory, but the provisions of the Electric Lighting (Clauses) Act of 1899, which are identical with the form of provisional order hitherto in common use, make certain regulations as to supply which ease the burden of the company.

By Clause 27 of the Schedule to the Act of 1899, which is now incorporated with every provisional order, undertakers (*e.g.*, the supply company) are bound, upon being required to do so by the owner or occupier of any premises situate within 50 yards from any

distributing main of the undertakers . . . . . to furnish and lay any electric lines that may be necessary for the purpose of supplying the maximum power to which the owner or occupier is entitled. The cost of any electric line to be used for conducting the current from the mains to the consumers' premises is to be borne by the supply company if it is only 60 ft. in length. The expense of providing additional wire shall, if the undertakers so require, be defrayed by the owner or occupier. The most important provision, from the undertakers' point of view, is contained in Clause 27 (2) (*b*), which provides that every owner or occupier of premises requiring a supply of energy, if required by the undertakers, must enter into a written contract with them to continue to receive and pay for a supply of energy for a period of at least *two years* of such an amount that the payment to be made for the supply, at the rate of charge for the time being charged by the undertakers . . . . shall not be less than 20 per cent. per annum on the outlay incurred by the undertakers in providing any electric line required under the section. The undertakers are also empowered (by Sec. 3) to demand security for the payment of all moneys to become due in respect of such supply; and in default of security being given they may discontinue the supply of electricity. By Clause 27 (5) the undertakers are relieved from the obligation to provide any supply unless they are reasonably satisfied that the electric lines, &c., on the consumers' premises are in good order and condition. The Board of Trade regulations go further than this. It is provided by R. (41) that the undertakers shall not connect the wires and fittings on a consumer's premises with their mains unless they are reasonably satisfied that the connection will not cause leakage exceeding $\frac{1}{10000}$ part of the maximum current supplied to the premises.

The Price of Electricity.—Regulations as to the price of electricity are to be found in Secs. 31 and 32 of the Schedule to the Electric Lighting Clauses Act, 1899, and the rules issued from time to time by the Board of Trade. The material provisions of the Act of 1899 are as follows:—By Sec. 31 (1) it is provided that the undertakers may charge for energy supplied by them to any ordinary consumer (otherwise than by agreement)—(*a*) By the actual amount of energy so supplied; or (*b*) by the electrical quantity contained in the supply; or (*c*) by such other method as may for the time being be approved by the Board of Trade.

The exact prices which may be charged are now set forth in the Fourth Schedule to the *Form of Provisional Order* published by the Board of Trade in 1899. In the Schedule the term "unit" means the energy contained in a current of 1,000 amperes flowing under an E.M.F. of 1 volt during the hour. When the undertakers charge by *actual amount*, they are entitled by Sec. 1 of the Schedule to charge at the following rates per quarter:—For any amount up to 20 units, 13s. 4d.; and for each unit over 20 units, 8d. Where they charge by the *electrical quantity* in the supply, they shall be entitled to charge according to the rates set forth in Sec. 1 of the Schedule, the amount of energy supplied to the consumer being taken to be the product of the electrical quantity and the declared pressure at the consumers' terminals as may be declared by the undertakers under the Board of Trade regulations. The "standard or declared" pressure at consumers' terminals is also provided for by the Board of Trade regulations under the Electric Lighting Acts, 1882 and 1888, Sec. (B), Sub-Sec. 4—8. Should any consumer at any time object to the method whereby he is charged, he may by one month's notice require the undertakers to charge him at their option either according to methods (1) or (2). [See Sub-Sec. (2)].

The result of this sub-section is that the option lies with the undertakers, and the consumer has in reality very little power. Suppose, for instance, the majority of the consumers in a district were charged according to electrical quantity, an application by one or two to charge according to "actual amount" could apparently be refused.

It is provided by Sub-Sec. (3) that before commencing to supply energy through any distributing main for the purposes of general supply, the undertakers shall, if the local authority are not themselves the undertakers, give notice to the local authority, and if the local authority are themselves the undertakers, by public advertisement, by what method they propose to charge for energy supplied through that main; and where the undertakers have given any such notice, they shall not be entitled to change that method of charging except after one month's notice of the change has been given by them, if the local authority are not themselves the undertakers to the local authority, and in any case to every consumer of energy who is supplied by them from the main.

The foregoing section applies merely to the *method of charging*. As we shall presently see, undertakers must not change the pressure of their supply without giving due notice to the public.

The prices to be charged by the undertakers for energy supplied by them must not exceed those stated in that behalf in the Special Order, or, in the case of a method of charge approved by the Board of Trade, such price as the Board of Trade determine on approving the method [Electric Lighting (Clauses) Act, 1899, Schedule Sec. 32 (1)].

Power to alter the original price to be charged for electricity is vested solely in the Board of Trade. The section which confers this power upon the Board is as follows:—

> Provided that if, in a case where the local authority are not themselves the undertakers, either the local authority or the undertakers, at any time after the expiration of seven years after the commencement of the Special Order, make a representation to the Board of Trade that the prices or methods of charge stated in the Special Order or approved by the Board of Trade ought to be altered, the Board of Trade, after such inquiry as they may think fit, may make an order varying the prices or methods of charge stated in the Special Order or so approved as aforesaid, or substituting other prices or methods of charge in lieu thereof, and the prices or methods of charge so varied or substituted shall have effect on and after such day as may be mentioned in the order, as if they had been stated in the Special Order: Provided also, that the prices and methods of charge for the time being in force may be altered in like manner at any time after the expiration of any or every period of seven years after they were last altered.

Authority to alter *prices* is thus vested in the Board of Trade, whereas the local authority has power to deal with and alter the standard pressure, subject to an appeal from their decision to the Board of Trade. (See Rule 6 of the Regulations of 1896.)

From a consideration of this somewhat complicated section, it becomes evident that undertakers cannot arbitrarily change the price of electricity. The provisions of the section have not often been called in question. This may be accounted for by the fact that the tendency in recent years has been for undertakers to lower rather than to raise the price of their current.

None of the foregoing provisions of the Electric Lighting Acts affect the

Penalties for Failure to Supply.—By Clause 30, the undertakers are made liable to a penalty not exceeding 40s. for each day on which they make default in supplying electricity. A glance at the above enactments will show the exact position of the supply company. Nothing is said in any statute which can be taken as excusing them from supplying to consumers who have their own plant, or to customers who, for their own convenience, only require an intermittent supply.

The foregoing provisions make it clear that undertakers must supply their current without fear or favour to all consumers within their district. As a matter of practice, in order to secure the custom of persons residing at some distance from the mains, the company will often defray the entire cost of connecting lines.

Raising the Price.—The question as to whether an electrical supply company can raise the price of electricity without notice has arisen in the case of gas supply. In the Commercial Gas Co. *v.* The Mayor, &c., of Stepney, the defendants were summoned to obtain payment of the sum of £917 8s. for gas supplied. It appears that by the Commercial Gas Co.'s Act of 1875, Sec. 53, the company were allowed to raise the price of gas if the rate of dividend be reduced. The defendant Corporation paid less than ordinary consumers, and when the company raised the price to the latter, the parish price was not increased. It was contended on behalf of the defendants, that inasmuch as they were under a quarterly agreement with the gas company, they were entitled to notice of any alteration in the price.

In the course of his judgment, Mr. Mead said that he had come to the conclusion that under the agreement the gas company had no right to raise the price of gas without reasonable notice. If they wanted to raise the price, then they ought to have given the local authority reasonable notice to put an end to the existing agreement. All the sections which had been quoted, when taken together, pointed to a special agreement as to the sum which the company were to charge to the local authority. [See the *Times*, January 24th, 1901.] This case is only important to electrical supply companies in so far as it affects their right to charge an increased price for their current. Unless very special provisions are inserted in the private Act of an electric lighting company, it seems that they are not at liberty to vary the terms upon which they supply electric current upon every occasion. Such alterations can only be made if a local authority or the undertakers, at any time after the expiration of seven years after the commencement of the order, make a representation to the Board of Trade that the prices or methods of charge stated in the schedule or approved by the Board of Trade ought to be altered, the Board of Trade, after holding an inquiry, may make an order varying the prices. The price to be charged for energy supplied to public lamps must be settled by agreement between the local authority and the undertakers, or in case of difference, by reference to arbitration, regard being had to the circumstances of the case, and the distributing or other mains which may have been laid for the purpose, and the prices charged to ordinary consumers in the district. There does not seem to be any machinery in the Electric Lighting Acts to enable a question of this kind to be re-tried.

There is no reason to think that the magistrates would decline to apply the above principle to the case of electricity supplied under special agreement.

Pressure of the Current.—A notable feature of all the provisions above referred to is the absence of any clause providing for the pressure at which electricity is to be supplied. This important subject is dealt with in the Board of Trade Regulations.

Failure to Supply.—If the company make default in supplying electricity, the question arises whether proceedings at law would avail the consumer, either in addition to, or in substitution for, the recovery of a penalty provided by Statute. This problem has not yet arisen, so far as we are aware, in relation to the supply of electricity, but it has been frequently discussed in connection with gas or water supply. The result of the decisions may be said to be that where a duty is cast by statute upon a company or person, and penalties are imposed for failure on the part of the company to perform that duty, the company are only liable to pay penalties [Atkinson *v.* Newcastle Waterworks Co., 2 Ex., D. 441]. Now it is clear that under the Electric Lighting Acts, 1882—1899, an electricity supply company are bound to furnish their current without favour or distinction to all persons within their district, and it is also clear that they become liable to penalties in case of refusal. Hence the jurisdiction of the courts is ousted. It might be argued that in many cases a company have been held liable both to penalties and to an action, but a reference to those cases will show that the double remedy is only available in respect of the commission of Acts which the company are prohibited from doing or suffering to be done. Thus, in Goodson *v.* Sunbury Gas Consumers' Co. [75 LT 251], it was held that an action would lie for nuisance which resulted in an injury to the plaintiff when driving through the streets, although the com-

pany were also liable to penalties under the Gasworks Act [10 V., c. 15].

In supplying current to any local board, the supply company should remember that by the Public Health Act, 1875, Sec. 174, Sub-Sec. 2, "Every such contract . . . . . shall specify some pecuniary penalty to be paid in case the terms of the contract are not duly performed." It has been decided in a police court that a contract for the supply of electric lighting for streets comes within this clause, and that in the absence of such a clause the company cannot recover the price of electricity supplied. [British Insulated Wire Co. *v.* The Prescot Urban District Council, August, 1895.]

Intermittent Supply.—Although an electric lighting company are bound to furnish an intermittent supply if so required by their consumers, there is nothing in the Acts which enables them to compel a consumer to take an intermittent supply.

Moreover, it is provided by Sec. 18 of the Electric Lighting Act, 1882 (45 and 46 Vic., cap. 56), that undertakers shall not be entitled to prescribe any special form of lamp, &c., to be used by any company or person, or in any way to control or interfere with the manner in which electricity supplied by them under that Act, and any license, order, or special Act is used. It should be remarked, however, that this section prohibits a consumer from using his supply in such a way as to interfere with the supply to other consumers, but the demand for an occasional supply could hardly be brought within the mischief, to the suppression of which this part of the section applies. Assuming the consumer uses the minimum amount of energy in the course of the year, or, at any rate, pays for the minimum amount which he undertook to purchase by his agreement with the company, he may avail himself of the supply of energy as little as he chooses.

BUSINESS NOTES.

Electrical Wares Exported.

WEEK ENDING JAN. 7TH, 1902.		WEEK ENDING JAN. 6TH, 1903.	
Adelaide. Teleg. mat.	Value £79	Adelaide	Value £47
Alexandria	707	Alexandria	404
Amsterdam	45	Auckland	18
Bangkok	110	Bangkok	210
Bombay	44	Beira	28
,, Teleg. mat.	63	Bombay	75
Brisbane. Teleg. mat.	156	,, Teleg. wire.	142
Calcutta	2,138	Brisbane	164
,, Teleg. mat.	194	Buenos Ayres	298
Canada (*via* the States)	145	Calcutta	1,477
Cape Town	193	,, Teleg. wire.	229
Colombo	217	Canada, *via* U.S.	48
Durban	690	Cape Town	558
East London	494	,, Teleg. mat.	446
,, Teleg. wire	485	Channel Islands	39
Fremantle	154	Christiania	130
,, Teleg. mat.	81	Colombo	191
Genoa	95	Copenhagen. Teleg. cable	55
Gibraltar	45	Durban	1,252
,, Teleg. buoys	125	,, Teleg. mat.	1,625
Hobart	278	Forcados	40
Kobe. Elec. cable	1,502	Fremantle	131
Lyttleton	80	Iquique	32
Madras	340	Lisbon	73
Melbourne	655	Madras	10
Perth	60	Malaga	7
Port Elizabeth	118	Malta	11
Rangoon	16	Melbourne	1,154
Rio Grande do Sul	48	Nagasaki. Teleg. cable	1,442
Rio de Janeiro	31	Nordenham. Teleg. cable	3,067
Rotterdam. Teleg. wire	40	North Atlantic. Teleg. cable	16,560
St. Petersburg	25	Oporto	6
Santos. Teleg. mat.	139	Ostend	160
Shanghai	143	Perth	306
Singapore	37	Port Elizabeth	266
Sydney	510	Shanghai	51
Tokio	80	Singapore	104
Trinidad	26	Sydney	836
Valparaiso	60	,, Teleg. cable	658
Wellington. Teleg. mat.	550	Tokio	34
Yokohama	3,569	Vera Cruz	1,034
,, Teleg. mat.	93	Wellington	197
		Yokohama	144
Total	£14,540	Total	£33,739

Foreign Goods Transhipped.

Cape Town.	Elec. lamps	Value £17

Rosling & Fynn, Ltd.—An extraordinary meeting of the shareholders of Rosling & Fynn, Ltd., was held at the offices of the company on Friday morning last to deal with the matter of a circular which had been issued by Mr. Rennie Lord, the secretary, informing the shareholders that the trustees of the debenture holders had taken possession of the assets of the company and giving notice of the two following resolutions:—

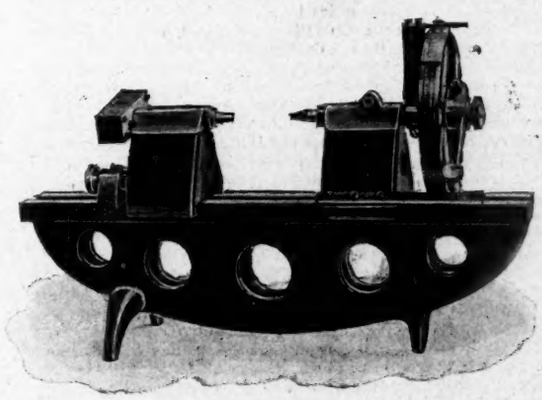
1. That it has been proved to the satisfaction of the company that it cannot, by reason of its liabilities, continue the business, and that it is advisable to wind up the same, and that the same be wound up accordingly.

2. That Mr. Wm. Martello Gray, of District Bank Chambers, Bradford, be appointed liquidator for the purpose of winding up the affairs of the company, at such remuneration as shall be fixed by the meeting, and with such persons, if any, as shall be appointed by the meeting, to act as a committee of inspection.

The meeting was well attended, and, these resolutions having been passed after a discussion occupying about two hours, the company will be wound up voluntarily in due course. A meeting of the creditors is to be held shortly to consider means of continuing the business under new proprietorship, and a notice has been issued offering the works for sale. It is understood that the company's difficulties have been caused solely by the length of time for which the business was unproductive owing to the removal from Trafalgar Street to the new works at Thornbury, premises which, together with the up-to-date plant therein, represented a value of nearly £30,000. In Bradford a considerable local interest attaches to the future of the undertaking, because this city has suffered greatly in the past from a too complete concentration of its capital and energy upon the staple textile industry, and the uprising of electrical undertakings was looked upon as one of the most hopeful developments in the direction of giving greater variety to the city's industries. It was decided to appoint a committee of inspection consisting of three members. Two have already been appointed, these being Mr. Percy Rosling, chairman of the directors, and Mr. Andrew C. Fox, representing the Bradford Old Bank. The third is to be appointed at the meeting of the company's creditors.

Mr. T. R. Ronald, general manager of the Law Guarantee and Trust Society, Ltd., is acting as agent of trustees for the debenture holders, in the default of this company. He notifies that all orders for goods to be supplied to Rosling & Fynn's works must be signed by himself or his agent, Mr. R. F. W. Fincham.

Fine Measuring Machine.—The accompanying illustration shows the 12 in. size of the fine measuring machine of the Newall Engineering Co., of 36, Featherstone Street, E.C. It consists essentially of a stiff bed casting, supported on three feet, and carrying two headstocks. One of these carries the divided index wheel and vernier plate. This is so arranged with the measuring screw that a reading such as ·8543 will be read as follows:—The 8 is read on the projecting horizontal bar above the wheel. It is the highest figure uncovered by the slide. The 5 is read on the division on the right-hand side of the wheel, and the 4 from the left hand side. In both cases it is the highest figure exposed past the zero on the vernier. The last figure can be



FINE MEASURING MACHINE.

easily read from the vernier by the usual method. The other headstock carries the anvil piece, and this presses upon a system of levers in a rectangular brass box seen at the back end of the anvil headstock. A movement of one-thousandth part of an inch causes the two needle pointers in this comparator box to move 1 in. relatively to each other. These needles enable every piece to be held at a uniform pressure between the points so that there is no need for the usual "feeler" of the ordinary machine. In its simplest form this machine is used to compare gauges with standard gauges, and it is employed by the Newall Co. to compare the limits of their limit gauges. (See ELECTRICAL REVIEW, August 1st, 1902.) By the addition of a divided standard bar and microscopic reading carrier, the machine may also be made to serve for general measurements, and for originating new work as well as for comparisons. The comparator needle box is a particularly useful and ingenious device.

Stromness Hotel.—The most northerly installation of electric light in Great Britain is in the Orkney Isles. Gas and paraffin have been rivals in Orkney for the past few years; but as gas costs from 6s. to 8s. per 1,000 cb. ft., it cannot be adopted as the universal light. About a year ago the first electric light was switched on at the Stromness New Hotel, Orkney. The installation is attended to by a young Orcadian, who never saw electric light before, and it has been maintained without a hitch throughout the year. The power is obtained from a Campbell oil engine, whose extreme power limit does not exceed that of the generator; owing to this the dynamo cannot be over-loaded. It is also impossible to jerk the accumulators, as the current is switched on and off by degrees not exceeding 6 amperes each step. Another feature is the ventilation of the wiring so that no damp can lodge in the tubes. The back connections of main switchboards and distributing boards, wiring and junction boxes can all be got at instantly, and a rewiring could be carried out without interfering with the visitors at the Hotel. The arrangement of the installation was designed by Mr. J. A. Liddle, of 28, Rutland Street, Edinburgh. Stromness Pier is lit with arc lamps supplied with current from the Hotel plant, which also supplies private villas to its full output.

Calendars and Catalogues.—From MESSRS. J. HALDEN & Co., of Manchester, we have received a wall calendar with very plain figuring and monthly sheets, each of which has a list of one or other of the firm's specialities in drawing office materials.

A show sheet for the wall has been issued by MESSRS. M. WESTON AND CO., of Birkenhead. It shows some excellent photographic views of the works where the Weston standard arc lamps are made. The firm claim to have been manufacturing arc lamps since 1874.

A large wall show list with calendar for the year has come to hand from the NEW BROTHERTON TUBE CO. The company's special "Excelsior" electric wiring conduits and fittings, &c, therefor are illustrated.

The Prometheus system of electric cooking and heating is very fully illustrated, and prices are given, in a new list just issued by the BRITISH PROMETHEUS CO, LTD., of 18, London Road, Kingston-on-Thames. The company has purchased the patent rights of the system for this country, and, we are informed, has equipped special plant for turning out the apparatus. It is its intention to hold large stocks in all standard voltages.

The EASTERN AND ASSOCIATED TELEGRAPH CO.'S have again brought out their useful pocket note book with calendar, also a list of telegraph rates, telegraph stations at home and abroad, tide table, and other information of interest to telegraph men. The list of dates of important events which have occurred in the world of cable telegraphy, also the handy map of the companies' systems, are good features of the book.

A small illustrated list of electric paper machinery has been issued by MESSRS. H. V. KRAMER & Co., of Lower Weston, Bath. A number of motor-driven machines employed in a paper mill power transmission installation are shown, for which class of work Messrs. Kramer have introduced a new variable speed motor.

The ELECTRIC AND ORDNANCE ACCESSORIES CO., LTD., has sent us one of its No. 21 circulars, giving particulars of the "Stellite" distribution system. This list has been so arranged as to illustrate all the combinations usually required, and in each case the price per way is stated, thus enabling any intending purchaser to see at a glance exactly what will be the cost of his requirements. Copies of the list will be sent on application.

The GENERAL ELECTRIC CO. (1900), LTD., have sent us a copy of their new Circular No. 0 1015, dealing with portable accumulators, hand lamps and electrical accessories for motor-cars. The catalogue represents an endeavour to embody all the articles which the G.E. Co. manufacture suitable for various forms of motor-cars, and also for purposes where portable lights are required. The various forms of pocket and portable accumulators for use with their small electric lamps have been standardised, and they are listed. The "Batten" rectifier for use on alternating current mains, and a small motor-generator for reducing the pressure on continuous current mains are shown, and both devices are capable of dealing with the current required for portable accumulators. The motor-car accessories include a large variety of articles, from sparking plugs and ignition cells to various forms of useful accessories. The company's Circular No. S. 1,020 is a new lamp list, in which they have embodied all the latest types of Robertson lamps. The prices have been reduced owing to the company's increased manufacturing facilities. High and low voltage lamps, tramcar lamps, "Sunshine" lamp for street lighting and shop windows, also crinkled and plain flame, tubular and other lamps are illustrated. In the high voltage lamps they are making a tube seal form of bulb, which they claim has considerable advantages over the older form.

The ELECTRICAL TRADES SUPPLY, LTD, of Birmingham, has sent us an excellent new catalogue cover, into which to insert their lists and leaflets as they are issued from time to time. It is a very neat thing, and is well worthy of a place on the desk of electrical engineers and buyers of electrical goods. We have also received a few of the company's price sheets of switches, electric fittings, accessories, Nernst lamps, &c.; others are in the press.

We welcome a very neat and convenient little standing calendar for the year 1903 from the ELECTRICAL SUPPLY CO., of Hatton Garden, to take the place of the one received from them last year, and which, by the way, has done excellent service.

MESSRS. D. GILSON & CO., of 360, Kingsland Road, N., have brought out an illustrated circular of their various switchwork.

Maxim's.—On Friday last the employés from the Incandescent Lamp Works of the Sir Hiram Maxim Electrical and Engineering Co., Ltd., held their annual social evening and dance at the St Peter's Institute, Buckingham Palace Road. Sir Hiram and Lady Maxim were among those present. Sir Hiram Maxim, in a short speech, said that if the company's business increased during the coming 12 months as it had during the past, they would on the next similar occasion need a much larger hall than the already large one they were in.

For Sale.—(DARWEN). Two complete sets Meldrum Koker stokers with forced draughts. See our advertisement pages this week.

The Belfast Corporation wants offers for second-hand plant as follows:—Four 120-I.H.P. gas engines, four 57·6-KW. dynamos, two 60-I.H.P. gas engines, two 26·4-KW. dynamos, and two spare armatures.

An electric fittings and brass foundry business in Birmingham, and the electrical engineering works of Messrs. Rosling & Fynn, Ltd., Bradford, are to be sold, both by private treaty. See our advertisement pages this week.

Entertainment.—The annual tea and entertainment for the wives and children of the employés at Messrs. Crompton & Co.'s works took place at the Corn Exchange, Chelmsford, on Saturday evening. Over 1,100 sat down to tea.

Trade Announcements.—The registered offices of the Amazon Telegraph Co., Ltd., have been removed to 42, Old Broad Street, E.C. Mr. Edmund Petley, F.C.I.S., has been appointed secretary.

The firm lately trading as E. Oppermann, engineer and gear cutter, 13, Abemarle Street, Clerkenwell, E.C., will in future be known as Oppermann & Sons.

Messrs. Rowland Carr & Co. have opened a showroom at 6—8, Lime Street Square, E.C., where many specialities for electric tramway and lighting work are on view. These include c.i. cable hangers, ornamental traction pole bases of various sizes, tramway switch pillars, arc lamp pillars and conduit sections; also roadway and pavement boxes, cut-out, joint and network boxes. The Trinidad bitumen and joint-box compound, for which Messrs. Carr hold the sole agency of the Asphaltic Co., and which is being supplied to a large number of electricity supply works in the United Kingdom, is also in evidence. The trade will be welcomed at this new showroom.

Messrs. Howard Jones & Co. have commenced business as electric storage battery experts and analysts at 68, Birmingham Road, West Bromwich.

Books Received.—"A Course of Simple Experiments in Magnetism and Electricity," by A. E. Munby. London: Macmillan and Co., Ltd. 1903. 1s. 6d.

"The Practical Electrician's Pocket-book for 1903," edited by H. T. Crewe. London: S. Rentell & Co., Ltd. 1s. and 1s. 6d.

"Municipal Trading." Paper by Hon. Vicary Gibbs, M.P. Industrial Freedom League, 53, Parliament Street, S.W. 6d.

Bankruptcy Proceedings.—A receiving order has been made on the petition of a creditor against A. E. Pemberton (Sale Electrical Co., Manchester).

First meetings and public examination in *re* W. Scholes (Scholes and Son, electrical engineers and contractors, Manchester), are to be held on January 14th and February 9th respectively.

Dissolutions and Liquidations.—Creditors of the Electrical Copper Co. must send particulars of debts, &c., to Mr. G. Revert, liquidator, 75, Gracechurch Street, E.C., by February 4th.

Messrs. H. Birch and G. K. Spivey (G. Spivey & Co., electrical engineers, Dewsbury) have dissolved partnership. Mr. Spivey will attend to debts.

The Simplex Electric Tramway Conduit Syndicate is to meet on February 3rd at Liverpool to hear an account of the liquidation from Mr. Ben Cookson.

January 17th is the last day for receiving proofs (J. H. Hilton, 7, Lothbury, E.C.) for intended dividend in *re* Harry South & Co., Ltd, London.

Private Lighting Plants.—Messrs. R. J. Nicholson and Co. have just completed a house lighting installation for Mr. Archibald, of Nunthorpe, near Middlesbrough. The plant consisted of an oil engine, dynamo and storage battery. By means of a friction clutch, the engine drives a small pump for drawing water from a well and forcing it to the cistern at the top of the house. The engine is by Campbell, the dynamo by Crompton, the battery by the Chloride Electrical Storage Co., Ltd., and the board was built by the contractors. The same firm also put in a complete house plant for Mr. Maude at Burton-in-Lonsdale a short time ago, the motive-power in this case being water; this was the third of these plants laid down within the last few months by the firm, who make a speciality of country house plants.

Ebbw Vale Collieries.—Messrs. Doherty & Donat, of Manchester, last month received the order for one of their Zschocke patent double chimney water-cooling towers, having a capacity of 320,000 gallons per hour, for erection at the above collieries, through Messrs Thornton & Crebbin, of Bradford, who are supplying the complete condensing plant. This brings the total of Messrs. Doherty's orders received during the year 1902 for their patent cooling plant to over 40,000 H.P.

Fire.—Early on Saturday morning a fire occurred at the premises of Mr. R. W. Ashley, electrical engineer, of Nottingham.

New Turn-switch.—We have received from Mr. C. Garnett, borough electrical engineer of Darwen, a model of a new turn-switch, designed by a resident of the town. The movement is ingenious, consisting of a spring-link loose-handle motion, which gives rapid make-and-break, and cannot be left or held in the intermediate position. The length of break, provision for fixing the leads, &c., are satisfactory. In its present form it appears likely to be somewhat costly, but the action is excellent, and perhaps the construction can be cheapened.

ELECTRIC LIGHT AND POWER NOTES.

Barnstaple.—The Corporation E.L. works are to be opened, and the supply of electricity commenced, on January 29th.

Batley.—The T.C. has declined to consent to powers being conferred upon Heckmondwike U.D.C. to supply energy within any part of the borough, but is not unwilling to consider any reasonable proposal for dealing with individual cases, where electricity is required in the portion of Batley adjoining Heckmondwike.

Bedford.—The T.C. has decided to appeal against the increased assessment of the electricity works. The increase is from £522 gross to £3,122 and £414 net to £1,982.

Belfast.—The City Council last week considered at great length a report of the city electrical engineer, Mr. V. A. H. M'Cowen, to the Gas and Electric Committee, on methods of charging for electricity supply. The report showed that last year, out of 204 towns with populations over 20,000, 122 employed the maximum demand system—though 40 of these stultified themselves by having an alternative flat rate—and an interesting curve was given showing the extremely short duration of the maximum load on the generating plant at Belfast. The charges there are 6d. for the first hour and 2d. afterwards, and Mr. M'Cowen showed that only 8 per cent. of the output was paid for at the 6d. rate, while 81 per cent. was charged at 5d. or less, 43 per cent. returning less than 3½d. By means of a diagram, it was made clear that the most profitable consumers were those charged at the lowest rate, while the 6d. consumers were actually supplied at a loss. Yet a strong set was made against the maximum demand system by certain members of the Committee, who were obviously either short-hour consumers themselves or were incapable of comprehending the system. That is the great and insuperable objection to the municipal management of highly technical undertakings. One of these gentlemen said:—"Would it not be a monstrous thing to say if he went into a certain shop in the morning, when the shop was practically deserted of customers, he should be compelled to pay three times the price which he would pay in the evening, when the shop would be crowded. The principle was the same as that which the Committee sought to apply to their customers. The expenses were exactly the same in the morning as in the evening."

It would be impossible to more completely misrepresent the maximum demand system of charging. As was pointed out by Mr. Andrews, chairman of the Committee—who, judging from his speech, fully understands the matter—the output last year increased to 1,557,000 units, as compared with 1,100,000 in the previous year; 115,000 lamps were connected and 22,000 more were applied for. This does not look like failure. Yet the Council refused to be convinced, and rejected the minute of the Committee approving of the maximum demand system.

Self-interest and ignorance are the curse of democratic institutions.

Bexley.—Last week an inquiry was held by Col. A. J. Hepper regarding the Council's application to the L.G.B. for the loan of £15,493 for the purpose of public and private lighting by electricity.

Bradford.—The second of the two new 2,000-H.P. engines at the Bradford electricity works was started this week, and there is now no further likelihood for some time to come of the scarcity of supply which has been felt in Bradford for some time past.

Bridgend.—The D.C. has received a notification from Mr. Hill, of the South Wales Electric Power Distribution Co., in which he promises to lay before the directors the D.C.'s request to the company to insert in their agreement with power consumers in that district a clause prohibiting them from using any of the energy supplied for the purpose of generating electricity for lighting purposes. But Mr. Hill does not think that the directors will agree. He considers the company's *bona fides* proved by the letter which they have written to their customers in the district, informing them that they will not be supplied with energy for the purpose of providing lighting.

Bury (Lancs.).—The T.C. on December 31st decided to apply to the L.G.B. for a loan of £35,000, the estimated amount needed to cover the exceeded expenditure on capital account, and also for extensions to mains and other electricity works.

Cambridge.—A committee recommended that Mr. E. W. Monkhouse should be engaged as expert to advise the Council as to whether it was desirable to accede to the application of the Cambridge Electric Supply Co., Ltd., for a prov. order, and if so, on what terms. The directors had asked that, as a large amount of capital would have to be expended, the Corporation should consent to the extension for 10 years of each of the periods when it might acquire the undertaking. It was decided that no agreement should be entered into with the company which involved any postponement of the period when the Council might acquire the undertaking, and it was also decided to oppose the application of the company.

Cardiff.—A L.G.B. inquiry was held on Friday relative to the application of the T.C. for a loan of £7,000 for electric light purposes. There was no opposition.

Chatham.—The Kent Electric Power Co. (who have recently acquired the Chatham undertaking of the Chatham Electric Lighting Co.) have opened new and commodious offices in High Street, Chatham. Mr. Kensit is the resident engineer for the district.

Dorking.—At the L.G.B. inquiry held on January 1st into the application of the U.D.C. for a loan of £20,000 for electric lighting purposes, opposition was raised by the Leatherhead and District Electric Supply Co., Ltd., and the Dorking Gas Co., both of whom were represented by counsel. Objection was taken to the former company's opposition, on the ground that it had no *locus standi*, as it was not a ratepayer. In reply, it was stated that, although the Council obtained a prov. order in 1897, nothing was done up to June last, and on June 30th the company gave notice that it was applying for the revocation of the order, and for the granting of a new order to the company. It was submitted that on the ground of competition the company had a clear *locus standi*. The inspector said he would hear the company's opposition, and take a note of the objection. For the U.D.C. it was stated that it had entered into an agreement with Messrs. Edmundson's Electricity Corporation for carrying out the order. The company had to complete the scheme within nine months of the loan being granted, pay all costs relating to the execution of the order, and pay to the Council each half-year sufficient to cover interest on loans and for the repayment of the principal, so long as the total should not exceed 6½ per cent. per annum. The charges for private lighting were not to exceed 7d. per unit for the first hour and 4d. afterwards; for heating, 4d. and 1½d.; and for street lighting not to exceed 2½d. The Council might determine the agreement at the end of 7, 10, 14, or 21 years. The company had given to the Council security in the form of £3,000 in debentures, which was as good as cash. For the Electric Supply Co., it was pointed out that it already supplied parishes adjoining Dorking. Its charges were the same as those proposed by the Council. At this stage, the inspector intimated that it was hardly worth while going further into the opposition until the decision of the B. of T. was given as to the application of the Electric Supply Co., because, if the application were granted, there would be no need for the loan, and the inquiry shortly afterwards terminated.

Dover.—A ratepayers' meeting was held at Dover on Tuesday to consider the proposal of the Corporation to take over the electricity supply undertaking at a cost of £155,960. There was much opposition, and a poll of the town was demanded.

East Barnet.—The Council has adopted an electric lighting scheme, at an estimated cost of £14,000. It is proposed to generate electricity with the aid of a dust destructor.

Erith.—The Council's electricity supply undertaking is to be inaugurated on Monday afternoon next, 12th inst.

Exeter.—There was formally laid on January 1st the memorial stone of the new electric light and power generating station, for which the Corporation has obtained borrowing powers to the extent of £68,000. It is to take the place of the hat factory, which hitherto has done duty in supplying the city's electric light. Increasing demand for light, and the City Council's decision to lay down an extensive system of electric tramways, necessitated the change. An almost ideal site was obtained at the canal head in immediate contact with railway and waterway systems, and fairly near the light and power area. The building, which is being built of brick, with freestone dressings, will have an engine room 103 ft. × 45 ft., boiler house 103 ft. × 56 ft., pump room, repairing shops, test room, and economiser chambers on the ground floor. On the first floor will be Committee room, switch rooms, mess rooms, stores and offices, all opening on to a gallery overlooking the engine room. Over the boiler house is storage for 800 tons of coal, and automatic stoking has been provided for in the loan, though whether it will be used is not finally decided. Altogether, the capacity of the building will be 2,500 H.P. The builders' work will cost £14,000, the site (two acres, of which one-third will be utilised now), £2,000, and the equipment (by the Westinghouse Co.), £30,000. Mr. Donald Cameron, late city surveyor of Exeter, is the architect, and Mr. H. D. Munro the electrical engineer. Mr. E. J. Dunville, J.P., seven years' chairman of the Lighting Committee, laid the stone in the presence of a large company.

Forest Row.—A scheme has been propounded for utilising a waterfall in the parish for generating electricity for public and private lighting purposes. A committee has been formed to consider the matter.

Gorton.—The U.D.C. has decided to offer its E.L. order to Manchester Corporation for a term of 18 years, provided all expenses incurred to date are refunded. This resolution has since been confirmed by the District Council. The Manchester Corporation will in all probability take up the order and supply electricity from the city. The district is a working-class residential and manufacturing one.

Hebden Bridge.—The Halifax Corporation Electricity Committee has offered to supply electricity to the U.D.C. on the following terms:—For a supply between 6 a.m. and 4 p.m., 1½d. per unit; between 4 p.m. and 6 a.m., 2¾d. per unit for a consumption up to 15,000 units per annum; 2⅝d. per unit between 15,000 and 30,000 units; and 2½d. per unit beyond, provided the maximum demand does not exceed 200 I.H.P. at a time.

Heckmondwike.—The U.D.C. on Monday decided to reduce the price of energy for motive power to 2d. per unit for intermittent use, and to 1d. per unit for constant use.

Kingswood.—The U.D.C. has appointed a committee to consider the details of the Bill of the Somerset and District Electric Power Co., which is seeking powers to supply electricty to the town and other districts in Somerset, Gloucestershire and Wilts.

Leek.—The North-Western Electricity and Power Gas Co. has asked the R.D.C. to support its scheme for supplying electricity for lighting purposes to various parishes in the district.

Limerick.—The Corporation has been served with a writ at the suit of Mr. P. Dillon, contractor, who claims £517 1s. 4d. alleged to be due to him as contractor to the defendants for

work done, which sum is certified as due to the plaintiff by Mr. J. Enright, engineer to the Corporation. Some weeks ago Mr. Dillon was ordered by the Corporation to stop the "permanent reinstatement" of the flagging ripped up for the laying of the electric cables in the streets of Limerick. The reason for this order was that the cost of this work was included in Mr. Dillon's tender for the electric installation, and should, therefore, not be regarded as an extra. At a special meeting of the Electric Lighting Committee, however, it was decided to recommend the Council to pay the amount claimed.

Linthwaite.—The U.D.C. has decided to consent to the application by the Corporation of Huddersfield to the B. of T. for a prov. order to supply electricity within the district.

London.—City.—Shortly after 4 o'clock on Friday afternoon last, a serious breakdown in the electric light supply occurred in the neighbourhood of the Mansion House. A number of banks and other business houses and shops were plunged into darkness. The street lamps were extinguished, and much inconvenience was caused to all having business to perform in the vicinity. Only the streets and buildings in the immediate neighbourhood of the Bank were affected. About 5 o'clock the majority of the lamps were lighted again. In reply to inquiries, the engineer to the City of London Electric Lighting Co. said that the failure in the current affected about 8,000 lights. This was only 2 per cent. of the lights in the City. Until the ground had been fully opened up, no exact cause for the occurrence could be assigned.

Loughborough.—At the meeting of the T.C. on Monday a letter was read from the Brush Electrical Engineering Co., Ltd., stating that owing to the difficulty of raising money for electrical enterprises at the present time, they saw no prospect of being able to give definite guarantees to start work in the combined electric lighting and tramways scheme in the immediate future. They took it, therefore, that, in view of the intimation that the Corporation must deal with the matter of electric lighting at once, they must abandon the idea of merging the two schemes.

Ludlow.—The T.C. has decided, subject to the sanction of the B. of T., to sell the electric lighting prov. order which the Corporation obtained three years ago to Mr. William Norton, a local auctioneer, who undertakes to register a company under the title of the "Ludlow Electric Light and Power Co., Ltd.," to work the undertaking. The price agreed upon provisionally is £225, and the company agrees to supply the Corporation with light at 4d. per unit, private consumers at 6d., and to destroy the combustible refuse of the borough at the rate of 1s. a ton.

North Wales.—The public authorities of Flintshire have decided to hold a conference relative to the Bill promoted by the North-Western Electricity and Power Gas Co. The idea is to secure uniform action, and not to oppose the scheme.

Nuneaton.—A scheme is under the consideration of the U.D.C. for lighting the streets of Stockingford with electricity.

Oban.—The electric light was switched on over a large portion of the town last week. It is expected that the supply will be in full operation at an early date.

Pontypool.—The D.C. has decided, after conference with an expert, not to exercise the option vested in it under the Pontypool Electric Light and Power Co.'s prov. order, of purchasing at the end of septennial periods.

Rathmines.—Last week a L.G.B. inquiry was held into the application of the U.D.C. for leave to borrow £20,000 for electric lighting purposes. Mr. R. Hammond gave evidence as to the extensions of the works for which the loan was required.

Rhyl.—At the adjourned inquiry, held last Tuesday by Mr. Bicknell, L.G.B. inspector, into an application by the Council to borrow a sum of £11,800 for electric light and refuse destructor purposes, it was stated that the Electric Light Committee met the previous evening, and decided to apply for £10,335 for electric light purposes, instead of £9,565; and instead of £2,233 for the refuse destructor, £475 would suffice. At the close of the inquiry the inspector said he was satisfied with the figures.

Southampton.—At the last meeting of the T.C., the Electricity Committee reported the receipt of a letter from the town clerk of Eastbourne, inviting the co-operation of the Committee in an appeal to the House of Lords to restrain the Inland Revenue authorities from imposing stamp duty on the purchase of goods, &c., in connection with electric light undertakings, and asking the Corporation to become one of 25 guarantors in the sum of £20 each, as it was estimated that, assuming the appeal to be unsuccessful, the amount to be paid would not exceed £500. The letter was referred to a sub-committee, with the town clerk and the borough electrical engineer, with power to guarantee a contribution up to £20. With reference to the claim of the Harbour Board for damage alleged to have been caused to their electric cranes by high voltage, it was reported that the Board were prepared to accept £300 in full settlement. It had been agreed between the parties to refer the matter to the arbitrament of Mr. John Christie, borough electrical engineer of Brighton. The Committee had congratulated the electrical engineer upon the successful manner in which he had provided for the heavy demand for electric light and power during three or four weeks in December without any breakdown. The report was adopted.

Southport.—There is every prospect that the electricity estate will at the end of the present financial year show a record in several particulars. For the first eight months ending November 1,044,123 units were sold, or an increase of 186,173 over the corresponding period of last year. During the year an important test was made with various grades of coal, and as a result 1·3 lbs. less of coal per unit sold are being used than was the case in the previous year. The coal contracts are working out at something like is. 6d. per ton less than in 1901. There are now 1,111 consumers of electricity in Southport, and the number is steadily increasing.

Stafford.—The R.D.C. has approved of the proposal of the Stafford Corporation to obtain a prov. order for the extension of the borough electric lighting system into parts of the parishes of Seighford, Castle Church, Tillington, Hopton and Coton and Berkswich.

Wakefield.—Last week an inquiry was held on behalf of the L.G.B. into an application by the Corporation for power to borrow an additional sum of £15,000 in connection with the electric lighting undertaking. There was no opposition.

Wrexham.—At a meeting of the T.C. on December 30th a letter was received from the L.G.B. intimating that they had decided to sanction a loan of £9,116 for electricity supply purposes, and the sanction of the additional £1,884 applied for would be held in abeyance.

ELECTRIC TRACTION NOTES.

Austria.—The new electric tramway between Linz and Klein-Munchen-Ebelsberg has just been completed and put in operation. The line is on the Thomson-Houston system, and has been carried out by the Austrian Union Electrical Co., of Vienna.

Batley.—It was reported, at the meeting of the T.C. on January 1st, that the negotiations with the B.E.T. Co. relative to the tramways had not been completed, and that the Electricity Committee had decided to make preparations for a municipal system. The lines already laid belong to the Corporation, and sample cars are to be inspected by a Committee, so that if the negotiations with the B.E.T. Co. for a lease of the tramways fall through, the Council will be in a position to run the cars without delay.

Birmingham.—A meeting of the City Council was held on 6th inst. when Alderman Beale, chairman of the Tramways Committee, moved a resolution that, notwithstanding any previous decision, the Committee be empowered to consider and report upon any proposal which might be received with respect to tramways in the city. He explained the negotiations which had taken place between Mr. Garcke, of the British Electric Traction Co., and himself, and said, according to the *Times* reports, that the Committee would consider any serious offer that might be made. A communication had been received from a firm of solicitors at Westminster expressing the hope that they would not be excluded from renewing their offer on behalf of certain clients if they wished to do so. In November last Mr. Garcke sent a series of proposals, forming one scheme, which he desired to be considered as tentative, but there were technicalities to be cleared up in connection with it, and it was pointed out that until the Council rescinded its resolution with regard to municipalisation, the proposals could not be discussed. A sub-Committee, however, had been appointed to consider them as soon as the Council sanctioned that course. Councillor Nettlefold thought that, if Birmingham had negotiated at the same time as the local authorities, they could have got more than they would get today now that the authorities had thrown in their lot with the British Electric Traction Co. An amendment was moved that six months' notice should be given to the tramways company to introduce a system of traction into the streets which would be acceptable to the Council, but this was defeated by a very large majority, and the resolution carried.

Brierley Hill.—The Tramways Committee is to confer with other local authorities with respect to the Bill of the Dudley, Stourbridge and District Electric Traction Co., and to oppose it.

Brooklyn.—The Brooklyn Elevated Railroad Co., after extensive trials, has placed a contract with the Westinghouse Co. to provide electro-pneumatic controllers on all its trains.

Burnley.—The Tramways and General Purposes Committee has recommended the T.C. to apply to the L.G.B. for a loan of £60,202 for the development of the Corporation tramways. Of this sum £24,002 is needed for the construction of three branch lines, £17,700 for additional cars, and £14,000 for tram-car shed accommodation.

Chatham.—The Chatham and District Light Railways Co. intend to lay down a new line in Middle Street, Old Brompton, therewith to connect the tramways of New Brompton, Brompton, and Gillingham with that of the main line to Chatham. This new line is necessitated on account of the recent fatal car accident at the adjoining (Westcourt) Street, which line has been abandoned by the company since the accident. It is proposed by the company to purchase, among other properties, ground and houses owned by the Admiralty, in order that a better curve can be procured at the spot. This proposal has been approved by the Lords of the Admiralty.

Chicago.—A huge electric traction venture is mooted at Chicago, with a proposed capital of $55,000,000, the money being found in New York and Chicago. The scheme is to tunnel the streets to make a complete loop of the business section, and to connect the line with a new elevated road to reach the stockyard district. The promoters are the directors of the New York Interborough Rapid Transit Co., now constructing the underground system in New York City.

Hove.—The Tramways Committee has recommended the T.C. to apply to the B. of T. at the earliest possible moment for leave to purchase that portion of the existing tramway which is in the borough, and to lodge a memorial against the Hove, Worthing and District Tramways Bill, because of the alleged non-compliance with Standing Orders.

Lancaster.—The Board of Trade inspection of the electric tramways (Scotforth and Williamson Park sections) was made by Col. Yorke and Mr. Trotter on Tuesday.

Liverpool.—The Tramways Committee has asked the Council to obtain sanction from the B. of T. to borrow £210,000 in order to carry out works provided for by the Tramways Provisional Order, 1901.

Manchester.—The energies of the Tramways Department of the City Council are now being concentrated upon the completion of the routes, not yet electrified, to the north of the city. The Middleton line, opened a fortnight ago, is to be extended to Middleton Junction, and a new line is being constructed along Conran Street, Harpurhey which will join a projected line from Rochdale Road to Oldham Road, within the city boundary, by way of Moston Lane, Dean Lane, and Lightbowne Road. On April 1st it is expected that electric cars will begin running from Manchester to Oldham, by way of Newton Heath and Failsworth. So far as population is concerned, this is one of the most important of the suburban districts of Manchester. The same day will witness the connection of the city with Ashton-under-Lyne, by tramways along Great Ancrats Street and Ashton New Road, serving the important colliery and manufacturing districts of Bradford and Droylsden; also along Fairfield Street and Ashton Old Road, through the equally important and populous townships of Openshaw and Audenshaw. With the opening of the routes to Oldham and Ashton, horse trams will practically disappear from the city. The construction of a circular route, which is to connect all the outer districts of the city, without crossing it, is also being proceeded with. This route will be a great convenience to vast numbers of people. It will begin at Queen's Road, Harpurhey, on the northern side of the city, and after traversing the outer districts of Ancoats, Gorton, and Longsight, will be continued along Dickenson Road, entering Wilmslow Road at Rusholme, and continuing by way of Moss Lane East to Brooks's Bar, from which place cars already run to the Hightown (Cheetham) district. Upon this route only "single-deck" cars are to be used, on account of the low archways of certain railway bridges which cross the roads. The vehicles will be of the type known as single-deck combination cars, open at both ends, but with covered centre. Before the end of the year it is expected the entire system of city tramways will be completed.

"Manchester Southern" Tramway Scheme.—The Eccles Town Council has had under consideration the Parliamentary notices and plans of the scheme (known as the Manchester Southern) for constructing a tramway from Barton Bridge, in the borough of Eccles, to Gatley, in Cheshire. The scheme includes the construction of a short length of line in Eccles, and, in view of the agreement with Salford, under which the Eccles tramways are worked, the Eccles Corporation will, on the recommendation of its Parliamentary Committee, oppose the scheme so far as it affects the roads in Eccles.

New York State.—According to the statistics of the State Railroad Commission during the fiscal year ended June 30th, 1902, the surface and elevated railroads of the city of New York carried 924,754,211 original passengers; that is, passengers paying fares. Counting the transfers, the total number of passengers carried was 1,160,030,344. For the subjoined figures we are indebted to our contemporary the New York *Electrical World*:—

	Original.	Including transfers.
Manhattan and Bronx ...	625,547,434	802,154,609
Brooklyn	299,206,777	357,875,435

The original passengers riding on the cars in Manhattan were distributed as follows:—On the street surface roads, 410,287,089; on the elevated, 215,259,345. There being no transfers on the elevated makes the total transfers on the street surface roads 176,726,464. These figures, when compared with those of the preceding year, show that the passengers carried decreased 7,895,446 on the street surface and increased 25,213,604 on the elevated. The decrease on the street surface roads of Manhattan and the Bronx was not in original passengers, but in transfers, as these figures will show:—

	1902.	1901.
Original passengers	410,287,089	392,117,069
Increase	18,170,020	—

This year there are 15 railroad companies operating in the territory of Manhattan and the Bronx, which is an increase of two companies over last year. The length of tracks operated by these companies is 216·491 miles, against 206·613 miles last year.

The surface and elevated roads of Brooklyn carried during the past year 357,875,435 passengers, including transfers. The original passengers numbered 299,206,777. There is no way to separate the elevated from the surface road passengers, for the report of the Brooklyn Heights Co. makes no distinction. The lines of this company carried during the year 296,534,777 passengers, including transfers, and 240,394,676 original passengers. The increase in total number of passengers was 10,719,524. The statistics of original passengers for both years are:—

	1902.	1901.
Original passengers	299,206,777	283,546,691
Increase	15,660,086	—

Eight companies operate the railroads of Brooklyn, which is unchanged from last year. The track mileage this year is 330·317; last year, 328·394.

These figures show that there were more than two millions of passengers carried on the cars of the several lines of railroads operating in Greater New York every day in the year. A great increase is going on at the present time.

Oldham.—The first section of the new electricity works undertaken by the Corporation last year was by the end of December brought near completion. Some difficulty had been anticipated from the preparation of the tramway lines for electric traction before adequate means existed for the generation of current, but the Electricity Committee were able to provide a temporary installation, which, on the whole, worked satisfactorily. The price charged to tramway account for current, viz., 2d. per unit, has been reduced to 1½d. The Committee is now in a position to supply electricity for private use, and an extension of the mains for this purpose is to be made to Hollinwood. The great work of the year in this borough has been the practical completion of the tramway undertaking. Only a short length of line in Union Street West remains incomplete. A new car shed has been built at Mumps, and in a few weeks the headquarters of the administrative staff will be removed to permanent premises. The department now owns 80 electric cars, of which 24 are of the single-deck saloon type, the rest being mainly two-deckers, carrying 43 passengers each. No complete financial statement has yet been published, but it is understood that the capital expenditure on the tramways to the end of last year was about £400,000. The decision of the Council to relay the two main routes as double track involved an additional outlay of about £40,000, but the money has been well laid out, and the public will benefit in the long run on the score of convenience as well as economy.

Omaha (Nebraska).—The Omaha and Council Bluffs Railway Co. was incorporated on December 22nd with a capital of $15,000,000, to take over and extend in six different directions all the street car lines in the vicinity, including a line from Omaha to Griswold, Iowa. In all about 200 miles of route will be operated. The company's powerhouse, from which all the lines will be worked electrically, is estimated to cost $750,000. Messrs. J. and W. Seligman, bankers, of New York, are chiefly interested in the promotion.

Paisley.—The negotiations between Mr. Wm. Murphy and the Paisley Tramways Co. for handing over the Paisley system to Mr. Murphy have now been concluded. Mr. Murphy will shortly get possession of the Paisley line, and will then commence his system of electric tramways, for which he received Parliamentary powers 18 months ago.

Preston.—The T.C. on January 1st adopted the recommendation of the Tramway Committee not to entertain the offer of the National Electric Supply Co. to supply power to the Corporation for the electric tramways. Alderman Foster, chairman of the Committee, said they felt that with modern machinery they could do as well as the company, if not better.

Rochdale.—The T.C. has applied to Wardle U.D.C. to extend the date for acquiring the tramway lines in Wardle district for a year, to December 31st, 1903.

Rotherham.—A trial trip on the Corporation tramways has just been made by the contractors. The car was run over the two completed sections of the track, from the car sheds in Rawmarsh Road to Effingham Square, and from that point to the pumping station on Fitzwilliam Road. The distance was traversed without the slightest hitch, and the car ran with perfect smoothness. Mr. Crombie (representing Messrs. Dick, Kerr & Co.) acted as motor man. Messrs. Kenndy and Jenkin have acted as consulting engineers; Messrs. Macartney, McElroy & Co. were contractors for the tramway and overhead work; Messrs. W. T. Glover & Co. for the cables. Mr. E. Cross is borough electrical engineer, and Mr. Williams assistant electrical engineer. Fifteen cars have now been delivered, 12 double-deckers and three single-deckers.

Southport.—There has been a considerable increase in the traffic receipts on the tramway system this Christmas and New Year as compared with the same period last year. The new route from Birkdale has been responsible to some extent for the rise in figures.

Stockport.—It has been decided by the Tramways Committee of the Corporation that application shall be made to the Board of Trade for power to borrow a sum of £14,083 for the purposes of the Stockport and Cheadle Heath tramway, and a further sum of £16,000 for the Gorton Road tramway. The doubling of the line at the bottom of Lancashire Hill, and the laying of a new line along Wellington Street, Lord Street and St. Peter's Square, is to be taken in hand at once. Passengers will be able, when the latter is completed, to travel from Manchester

direct to the centre of the borough. The traffic on the Manchester and Stockport route is one of the heaviest in the district. Alterations in the train service between the city and borough, for the current month, are significant of the effect upon railway receipts of this new form of competition. A number of express trains which formerly called at Stockport have ceased doing so. The completion of a loop line by the London and North-Western Railway Co., between Manchester and Wilmslow, will reduce the train accommodation for Stockport still further, with the result that an appreciably greater volume of traffic will be thrown upon the tramways.

Stroud.—On Friday the R.D.C. discussed the proposed scheme of electric tramways for the district, which will connect Stroud with the neighbouring towns of Chalford, Stonehouse and Nailsworth, and for which a Bill is being promoted in Parliament. Several councillors were in favour of opposing the Bill, unless the promoters guarantee to carry out the entire scheme, whilst others were of opinion that if this course were adopted the Bill might be dropped. Ultimately the Council appointed a representative committee to consider the details, with full powers to act.

Todmorden.—A committee is to consider the advisability of the T.C. obtaining power to construct electric tramways in the town.

Yardley.—What is described as a very good bargain has been made by the R.D.C. relative to the Birmingham District Tramways Bill. The Tramways Co. has agreed to immediately convert the tramways in the district into the overhead system. It is provided that the right of the Council to purchase the tramways within the district shall be postponed until the expiration of 30 years from the passing of the Bill; the company to pay all the expenses in connection with the promotion of the Bill; and to pay the following annual sums to the Council:—For the second five years after the passing of the Bill, £300; the next five years, £400; the next five years, £500; the next five years, £550; the last five years, £600. If the Bill as deposited does not become law, or if the company does not construct any one of the new or additional tramlines, the annual sums payable shall be reduced to one-half, and the first period of five years shall run from August 31st, 1903.

TELEGRAPH AND TELEPHONE NOTES.

American Pacific Cable.—Reuter says that the first messages by the American Pacific cable were exchanged between San Francisco and Honolulu on January 1st.

It is announced that the Commercial Pacific Cable Co.'s cable has now been completed between California and Hawaii, and that cablegrams by this route from the United Kingdom to Honolulu will now be accepted at 3s. 7d. per word. The American Pacific cable, the notice adds, is operated in the office of the landline system of the Commercial Cable Co. in San Francisco.

Mr. S. S. Dickinson, on behalf of the Commercial Pacific Cable Co., has selected sites for the landing of the company's cable at Manilla, Guahan Island (in the Lardones), and at Midway Island (in the Hawaii group). Mr. Dickinson also decided to take the cable round the Nero Deep, which his survey showed to be 27,000 ft. deep, situated between Guahan and Midway.

The Indian Telegraph Department.—The official report for the year ended March 31st, 1902, states that it was not till the year 1876-7 that the receipts of the Department showed a balance over working expenses. From that date until 1883-4 the balance of net revenue was erratic, fluctuating from 5·44 per cent. in 1879-80 to 1·19 in 1883-4, but since then it has been fairly consistently between 4 and 5 per cent., reaching a high water-mark in 1897-8 with 7·40. The capital expenditure to March 31st last totalled Rs. 7,46,39,538, and the figures for the year showed a surplus revenue to the Governmental general exchequer, after charging interest at 3½ per cent. per annum in accordance with the P. W. D. Code of 6½ lakhs of rupees. In the year under review the aggregate receipts declined from Rs. 1,14,98,682 to Rs. 1,11,14,161, caused by a fall in the "message" revenue of Rs. 6,10,191. While there has been a decrease in receipts there has, however, been no decrease in the number of telegrams. The cessation of hostilities in China caused a considerable fall in the revenue from State messages, which is in part responsible for the lowered receipts. In the case of private messages the decline is attributed to the diversion of a large amount of "foreign" traffic from the trans-Indian telegraph routes to the new direct South Africa—Australia cable, to the reduction of the telegraph rates between India and Europe, and to "the growing popularity of the *deferred* as compared with the *ordinary* and *urgent* classes for inland telegrams." During the year 772 miles of line and 8,708 miles of wire, including cable, were added to the Indian telegraph system, making a total at the end of the year of 55,827 miles of line and 190,887 miles of wire, the latter being made up as follows:—Railways, 64,912 miles; canals, 3,172 miles; telephones and private lines, 4,009 miles; general departmental lines, 118,794 miles. The gross receipts of the telephone companies during the year amounted to Rs. 4,63,843, an increase of only Rs. 28,767 over those of the previous year, the average annual earnings during the last five years having been Rs. 4,13,178. The following are some of the longer circuits on which automatic instruments (Wheatstone) are worked:—Bombay to Rangoon, 2,226 miles, with Nagpur, Calcutta and Akyab in translation; Madras to Rangoon, 2,040 miles, with Vizagapatam, Calcutta and Akyab in translation; Bombay to Calcutta, 1,223 miles, with Nagpur in translation; Madras to Calcutta, 1,037 miles, with Vizagapatam in translation; Bombay to Karachi, 1,002 miles direct.

Rochdale Telephones.—The Corporation on January 1st decided to adjourn the further consideration of the municipal telephone scheme *sine die*. Mr. Sharp said that what had occurred at Tunbridge Wells and Glasgow would induce the Council to vote in larger numbers against adopting the municipal telephone in the borough. A year ago the majority in favour of the scheme was but one.

The "Silvertown."—Mail advices dated December 17th show that the Honolulu Chamber of Commerce was preparing to celebrate with a general holiday the anticipated arrival of the trans-Pacific cable at that place on December 26th, the cable ship *Silvertown* being due on that day.

Telegraphic Interruptions and Repairs:—

Cables.	Interrupted.	Repaired.
Latakia-Cyprus	June 20, 1899	.. ..
Trinidad-Demerara No. 1	Aug. 27, 1900	.. ..
Trinidad-Demerara No. 2	Dec. 21, 1902	.. January 1
Dominica-Martinique	May 7, 1902	.. ..
St. Lucia-Martinique	May 7, 1902	.. ..
Guadeloupe-Martinique	May 7, 1902	.. ..
St. Lucia-St. Vincent	Nov. 18, 1902	.. ..
Martinique-Puerto Plata	July 10, 1902	.. ..
Guantanamo-Mole St. Nicholas	Aug. 4, 1902	.. ..
Cayenne-Pinheiro	Aug. 13, 1902	.. ..
Asaab-Massowah	Dec. 30, 1902	.. ..
Santa Cruz de Teneriff to Tejita de Teneriff	July 4, 1902	.. November 21
Reissi-Issa-Reissi-Yemani	Oct. 22, 1902	.. ..
Sitvebondo-Bandjermasin	Nov. 25, 1902	.. December 6
Zanzibar-Mombassa	Nov. 25, 1902	.. December 4
Cadiz-Teneriff	Nov. 3, 1902	.. ..
St. Jacques-Haiiphong	Jan. 3, 1903	.. ..
Falmouth-Bilbao	Dec. 18, 1902	.. ..
Landlines:—		
Majunga-Tananarive	Nov. 29, 1902	.. December 2
Route to Tientsin and Taku *via* Helampo	June 18, 1900	.. ..

Wireless Telegraphy.—Two of Marconi's experts are reported to be at Winnipeg arranging for a series of experiments in wireless telegraphy in the "Rockies." It is stated that Marconi will instal a trans-Continental service in Canada.

The first of a series of demonstrations of wireless telegraphy was given at the Naval and Military Exhibition at Manchester on Tuesday evening. The War Office authorities invited Mr. Marconi to demonstrate the value of his system at Manchester. During the course of the exhibition the receiving and transmitting apparatus was established at the exhibition and another station at Chester.

A *Times* correspondent writes to suggest an important practical use to which the Marconi system might be put. "Let ships generally be fitted with the requisite receiving apparatus, and at the precise moments of noon and midnight at Greenwich, let the fact be flashed over the entire world either directly from Greenwich itself, or, if that be for any reason impracticable, from half-a-dozen stations, themselves in direct communication with Greenwich, and placed in suitable geographical positions, so that every properly provided ship may be able to determine its longitude without the slightest trouble or risk of error."

The *Times* correspondent at Ottawa says that the promoters of the Canadian Marconi Co. announce that by the end of next summer there will be a complete system of wireless telegraphy in operation throughout Canada, extending from the Gulf of St. Lawrence to the Pacific Coast.

CONTRACTS OPEN AND CLOSED.

OPEN.

Adelaide.—February 16th. Tenders wanted by Deputy Postmaster-General, Adelaide, for the supply of 300 telephone wall sets complete (as per specification No. 1); 50 sets metal desk pattern telephones complete (as per specification No. 2); 2,500 fuse protectors for telephones (specification No. 3); 1,000 spare fuses (specification No. 4); Specifications and samples can be seen, and forms of tender obtained, at the General Post Offices, at Perth, Adelaide, Melbourne, Hobart, Sydney, and Brisbane.

Atherton.—January 23rd. Switchboards, transformers, pillars and cables. See "Official Notices" January 2nd.

Batley.—February 2nd. Feeders, cables, conduits, arc light columns, &c., station wiring, instruments, &c., steel poles and overhead equipment, and switchboard. See "Official Notices" to-day.

Bermondsey.—January 19th. Lamp columns, arc and incandescent lamps, switch pillars, &c. See "Official Notices" January 2nd.

Brighton.—January 26th. Overhead construction and equipment for tramways. See "Official Notices" to-day.

Bulawayo.—February 26th, 1903. Establishment and working of an electric tramway. See "Official Notices" Nov. 21st.

Bury.—January 26th. Traction accumulators and reversible booster. See "Official Notices" to-day.

Cleckheaton.—January 24th. The U.D.C. wants tenders for motor booster. See "Official Notices" to-day.

Colchester.—January 17th. Wiring, &c., for Essex and Colchester Hospital. See "Official Notices" December 26th.

Dundee.—January 17th. Electric lighting switchboard, boosters, balancers and switch gear for the Corporation electrical power station. See "Official Notices" January 2nd.

France.—January 22nd. The French Post and Telegraph Authorities in Paris are inviting tenders until the 22nd inst. for the supply of a quantity of electric cables. Particulars may be obtained from Le Sous-Secretariat d'Etat des Postes et des Telegraphes, 103, Rue de Grenelle, Paris, to whom tenders are to be sent.

Fulham.—January 14th. Two electric passenger lifts for the Guardians. See "Official Notices" January 2nd.

Guayaquil.—February 12th. The terms for the contract for lighting the city appeared in this column on January 2nd.

Hackney.—February 12th. 1,500-KW. steam dynamo and condenser, with electrically-driven pumps. See "Official Notices" to-day.

Hull.—January 21st. 15 double-deck single-truck cars, equipments and top covers. See "Official Notices" January 2nd.

Ipswich.—January 23rd. 26 electric cars, also one for street cleaning, watering and sanding. See "Official Notices" January 2nd.

Newport.—January 26th. Telephones, street pillars and 30 exchange boards for tramway system. See "Official Notices" to-day.

Rochdale.—January 13th. Electric wiring of the Free Library extension. See "Official Notices" to-day.

Salford.—January 10th. Two battery boosters for Strawberry Road Station. See "Official Notices" January 2nd.

St. Annes-on-Sea.—January 21st. Boilers, feed pumps, steam dynamo and switchboard. See "Official Notices" to-day.

Spain.—January 23rd. Tenders for the concession for the electric lighting of the town of Alcaniz during a period of 10 years. Tenders to El Secretario del Ayuntamiento del Alcaniz (Teruel), whence particulars may be obtained.

Spain.—January 25th. Tenders are being invited until the 25th inst. by the Spanish Post and Telegraph Authorities in Madrid for the establishment of a telephone line between Madrid and L'Escorial. Tenders are to be sent to La Direccion General de Correos y Telegrafos, Calle de Carretas, 10, Madrid, whence particulars may be obtained.

Stalybridge.—February 2nd. Electric tramcars with trucks and equipment complete, tower-wagons, overhead equipment and car sheds. See "Official Notices" to-day.

Stepney.—January 15th. 500-KW. steam dynamo. See "Official Notices" December 19th.

Stockport.—January 24th. 645 tons of grooved steel tram rails, 15 tons tie bars, also special work. See "Official Notices" January 2nd.

Stoke-upon-Trent.—January 14th. Destructor, boilers, pumps, conveyor, economiser, steam dynamos, balancer, boosters, switchboard, battery, mains, &c., crane, and workshop machinery. See "Official Notices" December 12th.

Sydney.—January 28th. Arc lamp pillars, brackets, arc lamps, controlling gear, &c. See "Official Notices" to-day.

Wallasey.—January 15th. Steam dynamo, Lancashire boiler, condensing plant and cooling tower. See "Official Notices" December 5th.

Wellington, N.Z.—January 21st. Supply and installation of all material, including power house equipment, overhead work, track work, feeders, tramcars, &c., for tramways. See "Official Notices" December 12th.

West Ham.—January 27th. The Council wants tenders for accumulators. See "Official Notices" to-day.

West Ham.—February 10th. Electrical equipment of 8 miles of track. See "Official Notices" to-day.

CLOSED.

Blackpool.—The Corporation Tramways Committee on December 31st accepted the tender of the St. Helens Cable Co., Ltd., for the supply of traction cable, that of the British Insulated and Helsby Cables, Ltd., for lighting cable; that of Messrs. Collier Bros. for trolley wire; that of Messrs. R. W. Blackwell and Co., Ltd., for bonds, and that of Messrs. White & Co., of London, for standards, brackets and other iron fittings for the pillars for the tramways.

Bristol.—The contract for two steam turbines for the electricity department, has been placed with Messrs. C. A. Parsons and Co. The foundations at Avonbank (second instalment), are to be put in by Mr. C. A. Hayes, at £10,969

Doncaster.—The Corporation has placed an extension order with Messrs. Willans & Robinson for a 360-H.P. engine for direct coupling to a Bruce Peebles dynamo.

Ebbw Vale.—Messrs. Thornton & Crebbin, of Hammerton Street Iron Works, Bradford, have received an order from the Ebbw Vale Steel, Iron and Coal Co, Ltd., for a large central condensing plant complete with cooling tower, to deal with the exhaust steam from their blowing engines.

Leicester.—The Electric Tramways Committee has accepted the following tenders for works required to be carried out in connection with the first section of the new electric tramway scheme:—Messrs. R. W. Blackwell & Co., Ltd. (£23,194), for overhead trolley wires, poles, brackets, wires, insulators, &c., for the overhead construction and equipment of the lines; also copper rail bonds at £1,921. Messrs. Blackwell & Co. will also supply bolts, nuts, and tie-bars. Messrs. T. Wragg & Sons, of Swadlincote, at £3,368, stoneware pipes and conduits for cables. Messrs. W. T. Glover & Co., Ltd. (£7,382), for feeder cables, telephone and test wires, roadway frames and covers, including maintenance for 12 months from the completion of the works. Messrs. Dick, Kerr and Co. (£28 417) for engines, generators, condensing plant and piping, boosters, motors, switchboard, accumulators, and other electrical equipment and travelling cranes at the generating station. The engines will be inverted vertical cross-compound Corliss condensing engines running at 95 revolutions per minute and will be manufactured by Messrs. Yates & Thom, Limited. The generators and switchboard will be of Messrs. Dick, Kerr's manufacture; the condensing plant of Messrs. Mirrlees, Watson & Co., Ltd.; the battery of the Tudor Co., Ltd.; the travelling cranes of Messrs. Jessop & Appleby. Messrs. Yates & Thom (£9,609) will supply the Lancashire boilers, economiser, steam, &c., pipes, feed pumps, storage tanks and general steam raising plant. The Cooper Patent Anchor Rail Joint Co. have the contract for anchor rail-joints at 12s. 3d. each joint. Rails and fish plates, North-Eastern Steel Co., £32,326; points and crossings, Hadfield's Steel Foundry Co., £13,041. The car tenders are still under consideration.

Manchester.—Messrs. Easton & Co., Ltd., have secured the order for the complete installation of electric lifts (19 in number) for the new Midland Grand Hotel at Manchester, now in course of construction.

Middlesbro'.—Messrs. Willans & Robinson, Ltd., have received an order for a 600-H.P. engine for Messrs. Dorman, Long and Co., for direct coupling to a Mather & Platt dynamo for electric power purposes. Messrs. Willans & Robinson have also received an order for three 75-H.P. steam dynamos for export to South Africa.

Southampton.—The contract for the supply of a new 50-ton electrical crane for the new graving dock at this port has been placed with Messrs. Stothert & Pitt, Bath.

Stalybridge.—The Stalybridge, Hyde, Mossley and Dukinfield Tramways and Electricity Board on January 1st accepted the following tenders:—Messrs. Witting Bros., Ltd., for motor-generators, combined change-over and equalising switches, starting motors and transformers, combined boosting sets, combined balancing sets, and air compressors; Messrs. Hope & Sons, Ltd., of Birmingham, for wrought-steel windows; the Tudor Accumulator Co., Ltd., for connecting up four batteries of accumulators and switchboard connections.

Wakefield.—The Board of Guardians has accepted the tender of Messrs. G. H. Woods, Slacke, & Co., of Blackburn, for extending the electric light to the old workhouse buildings, at £1,590. The extension will provide 400 inside and 21 outside lamps.

FORTHCOMING EVENTS.

Saturday, January 10th.—At 2.30 p.m. Northern Section of the National Electrical Contractors' Association. Annual general meeting at the County Hotel, Newcastle.

Tuesday, January 13th.—At 8 p.m. Institution of Civil Engineers. Paper on "Electric Automobiles," by H. F. Joel, Assoc.M.Inst.C.E.

At 8 p.m.—Institution of Electrical Engineers (Glasgow Section), at the Institution of Engineers and Shipbuilders in Scotland. Mr. Wm. A. Chamen will open a discussion upon "Up-to-Date Wiring in Connection with Corporation Supply."

At 8 p.m. London Electrical Contractors' Association, Restaurant Frascati, Oxford Street, W. Paper by Mr. R. Tweedy Smith (of Messrs. Turner & Co., hon. solicitors), on the projected legislative powers sought by the L.C.C. to enable Borough Councils to become electrical contractors.

Wednesday, January 14th. Institution of Electrical Engineers (Birmingham Section). Meeting postponed to January 21st.

At 7.30 p.m.—Institution of Electrical Engineers (Students' Section). Paper to be read "Some Difficulties which Students of Electrical Engineering meet with," by Mr. C. J. Green.

At 8 p.m.—Society of Arts. Paper on "Industrial Trusts," by Prof. W. Smart.

Thursday, January 15th.—Students' Engineering and Metallurgical Society. University College, Sheffield. Paper by Mr. J. R. Hyde on "Iron Founding."

Friday, January 16th.—At 8 p.m. Institution of Civil Engineers. Students' Meeting. Fifth annual lecture by Prof. W. C. Unwin. Subject:—"The Measurement of Water."

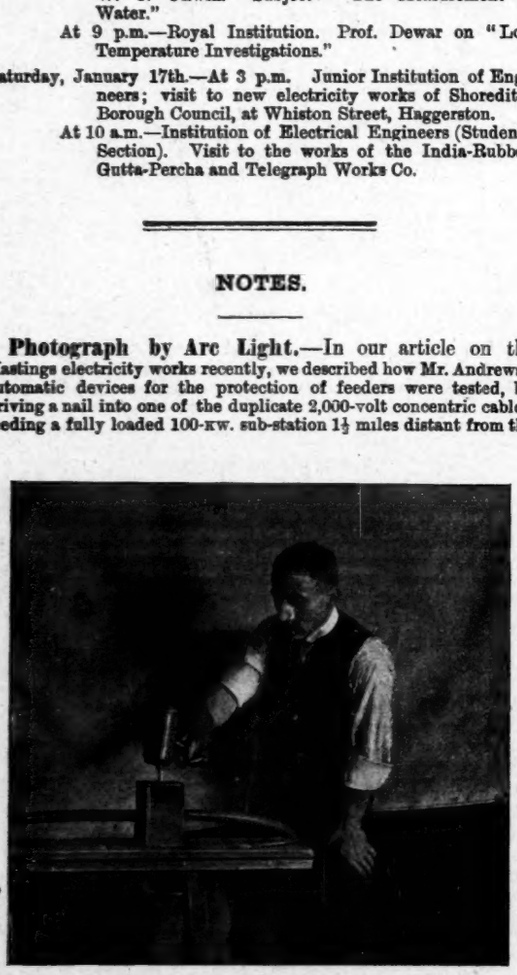
At 9 p.m.—Royal Institution. Prof. Dewar on "Low Temperature Investigations."

Saturday, January 17th.—At 3 p.m. Junior Institution of Engineers; visit to new electricity works of Shoreditch Borough Council, at Whiston Street, Haggerston.

At 10 a.m.—Institution of Electrical Engineers (Students' Section). Visit to the works of the India-Rubber, Gutta-Percha and Telegraph Works Co.

NOTES.

Photograph by Arc Light.—In our article on the Hastings electricity works recently, we described how Mr. Andrews's automatic devices for the protection of feeders were tested, by driving a nail into one of the duplicate 2,000-volt concentric cables, feeding a fully loaded 100-kw. sub-station 1½ miles distant from the generating station, without interrupting the supply. The photograph reproduced herewith was taken by the light of the arc resulting from the blowing of the high pressure fuse, within a few feet of the operator, under similar conditions. The position of the arc is indicated by the shadow on the background. This photographic feat is unquestionably unique. We are indebted to Mr. Andrews for the original, which, unfortunately, came to hand just too late for inclusion in the article mentioned above.

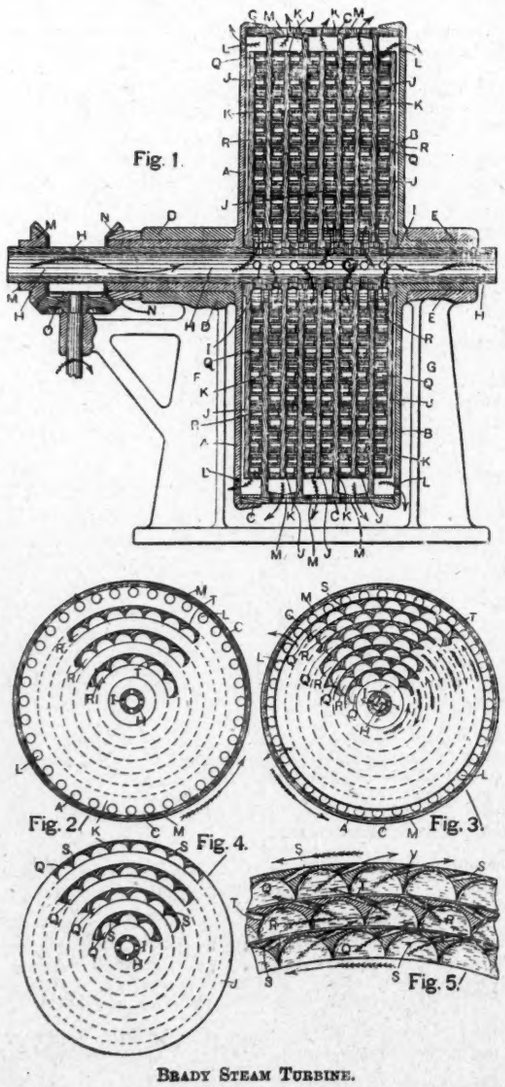


Shorting a 2,000-Volt Concentric Cable.

"Science Abstracts."—We would remind our readers who are members of the Institution of Electrical Engineers, that if they wish to receive *Science Abstracts* in 1903, they should apply to the Secretary of the Institution before 10th inst., if they have not already done so.

M.E.A.—The eighth annual convention of the Municipal Electrical Association is to be held at Sunderland from July 15th to 18th inclusive. Those who are willing to read papers on that occasion should send titles of suggested subjects to the secretary (Mr. C. McArthur Butler, St. James's Hall, Piccadilly) by January 31st, for the Council's consideration. The Council has decided to offer prizes of the value of five guineas, three guineas and one guinea for the best papers by Associates on some approved subject connected with municipal electrical engineering. Copies of the conditions can be obtained on application to Mr. Butler at the above address.

The Brady Steam Turbine.—The Brady turbine is one of those which appear to be coming forward in some quantity, and are arranged after the manner of a number of de Laval turbines in series, with the object of reducing the speed of revolution and improving the efficiency. It consists of a series of discs carrying on their faces projecting rings of buckets, or vanes, the rings of the one set of discs fitting closely in the spaces of the other set. Each ring in the elevation of a disc appears as a series of semicircular arches, out of which there is an inclined passage to lead the steam to the next tier. Steam enters at the centre through a number of passages in a hollow central shaft, escapes from ring to ring, and finally emerges expanded at the circumference, having run the gauntlet of seven or eight sets of vanes in all. One set of discs is coupled to the central shaft, or steam tube; the other set is coupled to an outer shell carried by a sleeve running on the said tube. There are five of the former discs and four of the latter; the outer two of the five carry vanes on one face only, all the others having vane rings on each face. As the steam expands in passing through the turbine, it passes outwards, and thus finds room for its expansion, and a high degree of efficiency is claimed for it in the *Iron and Machinery World*, a 90-h.p. wheel with 200 lbs. pressure and a ½-in. steam inlet running with 13 lbs. of steam per h.p.-hour. The diameter was 37 in. A promise is made of a test of a 10-ft. wheel to be made soon. Such a wheel would contain 62,000 expansion



Brady Steam Turbine.

chambers. The idea at the base of these multiple turbines is that each pass of the steam through a ring of blades or chambers reduces the revolutions necessary, or, more strictly, the vane velocity. In the single vane wheel the vanes ought to travel at half the speed of the steam jet. Six passes would reduce the velocity six-fold, so that a multiple turbine can easily be run as slowly as may be desired for any direct-connected work. Thus one may fix on 100 ft. per second as a suitable velocity of wheel, which corresponds with a steam jet at 200 ft. velocity. The steam loses, say, 200 ft. velocity at each pass, so that eight passes would represent an initial velocity of 1,600 ft. per second. In the Brady wheel, of course, calculation is on similar lines, but the different radii of the various rings of expansion chambers make a difference in the amount of expansion at each pass.

Obituary.—Mr. James Wimshurst, F.R.S., formerly of the Consultative Department of the Board of Trade, and widely known as an inventor of electrical influence machines, passed away on January 3rd, at the age of 70 years. Mr. Wimshurst was a great authority on iron shipbuilding, and for many years held a high position as a surveyor of iron ships, first to Lloyds and then to the Board of Trade, but he is best known to the scientific world through the beautifully simple and effective influence machines which he first brought out in 1883, and which are now to be found in most of the physical laboratories in the civilised world. Mr. Wimshurst was distinguished by his vigorous practical intellect, and his tireless pursuit of his object till success was achieved. Taking up the somewhat obscure subject of electrical influence machines comparatively late in life, with little or no previous technical training, he soon made himself thoroughly master of the subject at the bench of his private workshop. When an idea occurred to Mr. Wimshurst in his arm-chair it was not pigeon-holed to be tested at some indefinite date. Mr. Wimshurst stepped at once into his workshop where the idea was forthwith realised in mechanical form, and either dismissed as impracticable, or shown to be practicable and valuable. The achievements of such a mechanical genius as Mr. James Wimshurst appear to upset all the views of which we nowadays hear so much, as to the necessity and value of technical education to enable us to maintain our position in the vanguard of scientific and technical progress. At least, it shows that the inherent capabilities of the race count for as much as technical education. Mr. Wimshurst was a member of the Institution of Electrical Engineers, and of the Physical Society, and was made an F.R.S. in 1898. He was also a prominent Fellow of the Röntgen Society, and in his later years devoted much of his attention to the application of the influence machine to Röntgen ray work. The branch of electrical work to which Mr. Wimshurst devoted himself had little or no money in it; his chief stimulus was consequently an honourable ambition to distinguish himself in the ranks of pure science.

We sincerely regret to learn that Mr. J. S. Highfield, so well known to our readers as the Corporation electrical engineer of St. Helens, and who had only lately succeeded in obtaining the important appointment of engineer-in-chief with the Metropolitan Electric Supply Co., has been plunged into grief by the death of his wife. A child was born to them not many days previously. Mr. and Mrs. Highfield had only been married for two years, and this sad loss coming to Mr. Highfield practically on the eve of his departure for London, will evoke the sympathy of all electrical engineers.

An Auditor on Municipal Finance.—We have pointed out only too often that municipalities are working on a totally false basis in preparing their annual accounts. Mr. H. W. Pulleyn, the professional auditor of the York Corporation, in his report on the city accounts for the year ended March 31st, 1902, makes the following observations as to the electric lighting undertaking:—"I observe with regret that the members of the Council have not considered it necessary to adopt the recommendation contained in my last report, regarding the advisability of charging depreciation against the electric lighting revenue account. Having regard to the fact that the Local Government Board allow 25 years for the redemption of your electric lighting loans, it may fairly be assumed that the average life of the assets, acquired with the money provided by such loans, is less than the authorised term for repayment, and therefore the provision out of revenue for sinking fund instalments to redeem the loans is not of itself sufficient. This financial policy will ultimately result in the cost of replacement of plant falling against the year in which such replacement has to be made, instead of distributing the cost of same evenly over a period covering the life of the plant. Consequently revenue will be overstated during the earlier years of the undertaking, at the expense of the later years. Under these circumstances, I feel obliged to point out that any future balance of profits apparently available for the relief of rates will be purely fictitious unless the claims of depreciation are recognised." There are none so blind as those who will not see, and we do not suppose the Corporation will be less blind than its compeers.

Personal.—Mr. Wallace, manager of the Tunbridge Wells Municipal Telephone Exchange, has been appointed manager of the National Co.'s Exchange at Bradford.

Mr. J. Tranter, manager of the National Telephone Co.'s Exchange at Kendal, has been transferred to the Blackpool and Fleetwood Exchange. Mr. W. Shea, of Blackpool, goes to Stockport, and Mr. W. H. Walmsley, of Stockport, to St. Helens and Wigan.

It is said that Mr. C. H. Tweed, the chairman of the Great Southern Pacific Railroad Co., is coming to this country to join the firm of Speyer Bros., of London, for the purpose of taking charge of the financial work of the District Railway when electrified, and also in connection with the Perks and Yerkes tube schemes.

On the 2nd inst., at the Royal Hotel, Gateshead, the employés of Messrs. Clarke, Chapman & Co.'s electrical department presented their manager (Mr. Mansell) with a very handsome chiming timepiece, and a gold bracelet for Mrs. Mansell, on the occasion of his leaving the services of the company. The presentation was made by Mr. Corbett.

Dr. Paul Hirsch has joined the staff of the "Lister" Electric Manufacturing Co., of Dursley, as chief designer.

On December 23rd the cable department of the National Telephone Co.'s Edinburgh centre held their first annual supper. Mr. F. W. Gaskins was presented by his staff with a case containing four pipes, as a token of respect. Mrs. Gaskins was also presented with an umbrella.

Operation of Alternators in Parallel.—At the November meeting of the Société International des Electriciens, M. de Marchena read a paper on the speed regulation of alternators running in parallel. According to a summary of the paper appearing in the New York *Electrical World*, the author considers that parallel running of alternators is very greatly influenced by the governor action, a fact which has been generally overlooked by preceding writers, at all events, in France, who have given rather too much importance to the question of irregularity during one revolution of the fly-wheel. According to M. de Marchena the frequency of pulsating motive power is too high compared with the frequency of the oscillations proper of the alternator for permitting angles of displacement between alternators to attain to a dangerous value. On the contrary, the irregularities of motive power arising from instability of the governor are liable to produce very considerable displacements, resulting in dephasing or breaking down of alternators. The author examines the laws which govern centrifugal governors, and particularly the relations which exist between the positions of equilibrium of the governor sleeve and the variations of speed produced by variations of the force acting on the governor. He considered the oscillations of the system composed of the governor and fly-wheel, and the frequency of the first oscillations, that is, the oscillations of the governor; also the influence of the damping effect and the conditions to fulfil for a given damping effect to prevent oscillations of the second class, that is, of the governor and the fly-wheel from taking place. The author gave a formula giving the proportions of fly-wheel to be used for given conditions. He examined afterwards the working conditions of the governor when the alternator is connected with a network. He showed that the pendulum motions and greatly variable frequencies produced through irregularities of motive power or by the quick fluctuations of load, give rise in the governor action to oscillations, the amplitude of which depends upon the oscillations proper of this governor, as well as on its damping effect. He examined in each case the conditions of resonance which may be obtained, and the consequences. In order to obviate these inconveniencies, it has, up till now, been the endeavour to realise a very strong damping effect—at least temporarily, for the time corresponding to these abnormal conditions. M. de Marchena approved of Mr. Emmet's arrangement of dash-pot, which he thinks can sometimes give good results. He, however, estimates that it is a more rational solution of the difficulty to entirely suppress the cause of these oscillations by making the governor independent of the influence of the pendulum motions of the alternator. He, therefore, proposed to run the governor not by the machine itself, but by the use of an induction motor connected to the network. This motor not depending on individual oscillations of the machine, will not change its speed, and will only act on the governor when the frequency of the network is modified. The writer cited a test made with this system in a large hydraulic generating station in the Nice district, including turbines of 1,000 H.P. each. Special dispositions are employed for avoiding the troubles liable to result from accidental stopping of the motor. The first series of tests gave incomplete results on account of the excessive slip of the induction motor, which was too small. A new series of tests were made, however, with a larger motor, and the results are stated to have been entirely satisfactory. The pendulum motions which were experienced at first entirely disappeared. It is anticipated that this system is likely to be of general use, and the author expects it to be shortly employed for facilitating the parallel running of stations separated by long distances.

Telegraph Engineers for the Somali Campaign.—At Aldershot last week, Lieut.-General Sir John French, commanding the 1st Army Corps, inspected the 3rd Division Telegraph Battalion Royal Engineers, which embarked on 2nd inst. on the *Simla* for Aden, *en route* to Berbera. The troops numbered 60, and were in command of Captain G. B. Roberts and Lieutenant H. L. Mackworth, D.S.O.

The Late Mr. Bathurst.—All having claims upon the estate of the late Mr. Frederick Bathurst (Armorduct Electric Conduit Co.) are requested to send particulars to Mr. Hervey Bathurst, of 6, Loudoun Road, St. John's Wood, to whom letters of administration have been granted, by February 9th.

Breaking of a Fly-Wheel.—On 29th ult., at Bootle, Mr. S. Brighouse, county coroner, held an inquest respecting the death of Frederick James Stratford, on Christmas night, through the breaking of the fly-wheel of an engine used to drive electric lighting machinery at the brick and tile works, Orrell, near Bootle. Mr. G. W. Hubbard, engineer and electrician at the works, stated that on the night in question he was inside the building in which the engine and dynamo were. About a quarter to five there was a loud crash, and the building was plunged into darkness. When a

light was procured, the place was found in a state of wreck—the fly-wheel had broken. The machinery had been examined that evening before it was started, and the speed of the engine was not greater than usual, about 130 revolutions per minute. About a quarter of an hour before the accident occurred, witness had tapped the wheels with a hammer, and found them tight and in order. Deceased was discovered lying on the ground unconscious, with a wound on his head. The machinery had been inspected by one of the inspectors of workshops and factories, and found to be in order. A verdict of "Accidental death" was returned.

Calcium Carbide in the United States.—The German Consul-General in New York has recently sent home a report upon the calcium carbide industry in America. The only manufacturer of carbide in the States is the Union Carbide Co., of New York. Its factory at Niagara Falls has a present capacity of 50 to 60 short tons per diem, but it is said to be now in process of enlargement to a total possible output of 100 tons per 24 hours. The cost of making the carbide, f.o.b. railway wagons, Niagara Falls, is reputed to be $24, export carbide being sold f.o.b. ship, New York, at $50, all of it being sent from the works to the coast by train. For the home markets the company has a number of selling depôts distributed throughout the country; the price in the North-Eastern States, free on railway wagons, being $70 per ton in lots of 1 ton upwards, and $3.75 per 100 lbs. It is packed in 100-lb. drums. The consumption of carbide has increased notably during the past two years, chiefly owing to the invention and use of better acetylene generators than those which were formerly employed. The material is graded into three sizes, which range between 3½ and 2 in., 2 and ½ in., and ¼ and $\frac{1}{16}$ in in diameter respectively. Most new American acetylene generators take the medium-sized carbide. Granulated carbide is handled by a separate company in New York, which exports the bulk of the material principally to the Philippines and the Argentine Republic. The Union Carbide Co. employs rotary continuous electric furnaces, and works up the dust produced on crushing the make with fresh charges. According to the Consul, foreign carbide would be welcome in the States owing to the high price of the local product; and if it could be sold c.i.f. New York at $50 per short ton, in the three popular sizes, and of good quality, it should find a ready market. At present there are 186 firms engaged in making acetylene apparatus of different kinds, and the use of the gas is constantly spreading in rural districts, especially in houses, hotels and the like which are only occupied part of the year. The gas is also finding acceptance for the illumination of railway coaches, motor cars, and cycles, and for the supply of portable powerful lights such as those required by earthwork contractors.

Cable Companies' Dinner.—On Thursday evening last, the 1st inst., the staffs of the Cable Companies held their 10th annual dinner and smoking concert at the London Tavern, Fenchurch Street. About 100 were present, and did full justice to the admirable fare provided by mine host, Mr. Ross. Mr. Norton (Eastern Co.) occupied the chair, Mr. Mockford (Anglo Co.) the vice-chair. The dinner was followed by a very enjoyable smoking concert.

Christmas Tree Illumination.—The Christmas tree at St. Bartholomew's Hospital, on Christmas day, was lit up by electric light, installed by the British Electric and Telephone Co. The accumulators were lent by the Electric Power Storage Co., and the multi-coloured incandescence lamps by the Edison and Swan Co.

Appointments Vacant.—An assistant is required at Maidenhead at £80, and a telephone manager for Brighton Corporation system. See "Official Notices" to-day.

THE CENTRAL STATION ENGINEER.

On Christmas Day the Electric Lighting and Tramways Department of the Rochdale Corporation held its first annual dinner and social gathering at the electricity works, about 50 being present. Mr. ATCHISON, the borough electrical engineer, presided.

The Dundee Committee, in accepting Mr. TITTENSOR'S resignation consequent on his appointment to Preston, has placed on record its high appreciation of his services during the period he held the office of city electrical engineer.

The Electrical Supply Committee of St. Helens has recommended Mr. E. M. HOLLINGSWORTH, deputy electrical engineer of the borough, for the position of chief electrical engineer, vacant by the departure of Mr. J. S. HIGHFIELD to take up the position of chief engineer to the Metropolitan Electric Supply Co.

The Harrogate borough electrical engineer and Mrs. Wilkinson recently entertained the employés of the electricity department and their wives to dinner in honour of Mr. WILKINSON'S recent marriage. About 70 sat down at the Salisbury Hotel.

Mr. FRED. THOMSON, station engineer of the St. Andrew's Cross Electricity Works, has received a presentation from the employés there and his fellow officials on the occasion of his leaving the Glasgow Corporation employment, after 10 years' service, to take up an important appointment under the Calcutta Electric Supply Corporation.

Morley T.C. on Monday appointed Mr. JOHN ELLIS, of Micklefield, as borough electrical engineer, at a salary of £200 per annum.

The Bristol Corporation has appointed Mr. A. E. BRYANT, at a salary of £143 per annum, and Mr. G. E. F. WEBBER, commencing with a salary of £104, to the staff of assistant engineers.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

British Thomson-Houston Co., Ltd. (47,982).—This company's annual return was filed on November 14th, when 32,531 ordinary and 40,000 preference shares were taken up out of a nominal capital of £4,000,000 in 40,000 preference and 40,000 ordinary shares of £10 each. £10 per share has been called up on 32,531 ordinary and 40,000 preference shares, resulting in the receipt of £681,932 10s.; £43,377 10s. remains in arrears; 7,469 ordinary shares are considered as fully paid. Mortgages and charges: £200,000.

Thompson, Ritchie & Co., Ltd. (34, Buckingham Gate, S.W.).—A postponing deed, prolonging the effect of a charge contained in £1,900 debentures, part of a series securing £3,000, has been registered. Property charged: The company's undertaking and property, present and future, including uncalled capital. Resolution for extending time passed November 27th, 1902. Trustees: Right Hon. J. B. Lilford, Hon. S. Powys, and H. F. Acland-Hood.

Electric Lighting Boards, Ltd. (64,543).—Issue on December 9th of a debenture for £400, part of a series created March 10th, 1902, to secure £20,000, charged on the company's undertaking and property, present and future, including uncalled capital. Trustee, Gen. S. J. Nicholson. Total amount previously issued of same series, £19,900.

Pulford Bros., Ltd. (Electrical Engineers, Liverpool) (63,544).—£500 debentures, dated December 10th, 1902, charged on the company's undertaking and property, present and future, including uncalled capital (if any) have been registered. No trustees.

Guildford Electricity Supply Co., Ltd. (36,725).—Issue on December 16th of £1,000 debentures, part of a series created November 19th, 1900, to secure £15,000, charged on the company's undertaking and property, present and future, including uncalled capital. No trustees. Total amount previously issued of same series, £10,700.

St. Helens Cable Co., Ltd. (62,741).—Issue on November 27th of £15,000 second debentures, part of a series unlimited in amount, created by resolution of November 24th, 1902. Property charged: the company's undertaking and property, present and future, including uncalled capital. Holders: W. Windle Pilkington, St. Helens (£7,500), and J. Beecham, St. Helens (£7,500). No trustees. Total amount previously issued of same series £145,500.

Cryselco, Ltd. (Electric lamp manufacturers, Bedford) (57,218).—£8,000 debentures, dated November 25th, 1902, charged on the company's undertaking and property, present and future, including uncalled capital, as a floating security, subject to prior charges for £5,000, have been registered. Holders: F. W. French, Eye, Suffolk; and M. Griffith, Stock Exchange, E.C. No trustees.

Uxbridge and District Electric Supply Co., Ltd. (62,706).—Issue on December 18th of £1,000 debentures, part of a series created July 18th, 1901, to secure £20,000, charged on the company's undertaking and property, present and future, including uncalled capital. No trustees. Total amount previously issued of same series: £16,000.

Mather & Platt, Ltd. (60,387).—This company's annual return was filed on September 19th, when 32,505 preference and 40,000 ordinary shares were taken up out of a nominal capital of £775,000 in 37,500 preference and 40,000 ordinary shares of £10 each. £10 per share has been called up on 21,705 preference and 2,500 ordinary shares, resulting in the receipt of £242,050. £483,000 is considered as paid on 10,800 preference and 37,500 ordinary. Mortgages and charges *nil*.

Witting Brothers, Electrical Engineers and Contractors, Ltd. (71,038).—This company's annual return was filed on October 14th, when the entire nominal capital of £40,000 in 1,150 "A" ordinary and 850 "B" shares of £20 each had been taken up. £4 per share has been called up on 850 "B," and £3,400 has been received. 1,150 "A" shares are considered as fully paid. Mortgages and charges *nil*.

Electric Railway and Tramway Carriage Works Co., Ltd. (67,082).—This company's annual return was filed on October 16th, when the entire capital of £150,000 in £5 shares had been taken up and paid in full. Mortgages and charges: £50,000 (debenture stock).

Dick, Kerr & Co., Ltd. (63,407).—This company's annual return was filed on November 12th, when 24,000 preference and 32,000 ordinary shares were taken up out of a nominal capital of £650,000 in 70,000 preference and 60,000 ordinary shares of £5 each. £5 has been called up on each preference share, and £120,030 has been paid. The ordinary shares are considered as fully paid. Mortgages and charges: £150,000. Subsequently to date of return 10,052 preference shares have been allotted, considered as fully paid.

Traction Co. of the United Kingdom, Ltd. (62,634).—Issue on December 23rd of £1,600 debentures, part of a series created same date to secure £3,000, charged on £5,000 due from the Traction Development Co., Ltd., and the company's undertaking and property, present and future, including uncalled capital. Holders, Lloyd's Bank, Ltd. No trustees.

North British Electrical Co., Ltd. (74,532).—A debenture for £359, dated December 22nd, 1902, and a covering agreement dated December 18th, relating to issue thereof, have been registered. Property charged, the company's undertaking and property, present and future, except uncalled capital; holder, G. Smith, Vernon Avenue, Eccles.

Ingleton Electric Lighting and Power Co., Ltd.—Issue on December 23rd of a debenture for £100, part of a series created August 8th, 1904, to secure £450, charged on the company's undertaking and property, present and future, including uncalled capital, subject to £2,200 prior debentures. Holder, J. C. Walker, Glenholme, Ingleton. No trustees. Total amount previously issued of same series, £200.

Newmarket Electric Light Co., Ltd. (44,450).—Issue on December 15th of £500 debentures, part of a series created October 16th, 1890, to secure £15,000, charged on the company's undertaking and property, present and future, including uncalled capital. Trustees, G. H. Verrall, Newmarket, and F. E. Gripper, Bread Sanctuary Chambers, S.W. Total amount previously issued of same series, £12,900.

SUPPLY STATION ACCOUNTS.

Cheltenham Corporation Electricity Accounts.

The retrograde movement indicated in the accounts of the Cheltenham Corporation electricity department which we analysed a year ago has been arrested, and the last published figures show an improvement, although the results can hardly as yet be regarded as satisfactory. The loss is still large, but it is only three-quarters of what it was. The increase in output is very considerable, and there seems to be plenty of scope for the business to develop, yet the ratio of maximum load to units sold seems to be tending in the wrong direction for economy in the costs.

General Statement.

	1900.	1901.	Inc.
Total capital expenditure ...	£112,827	£141,545	£28,718
Number of units sold	653,364	970,333	£316,969
Number of lamps connected ...	35,002	35,897	895
Maximum load in KW.	560	937	377
Gross revenue	£10,086	£13,082	£2,996
Gross expenditure	£7,608	£8,007	£399
Gross profit	£2,478	£5,075	£2,597
Average price per unit sold ...	3·66d.	3·22d.	—·44d.

The number of private consumers was 491 at the beginning of the year and 573 at the end of the year. Public lighting has been increased from 263 to 361 arc lamps, and in addition there are 20 incandescents. The proportion of units sold was:—

Year.	Units generated.	Units to street lamps.	Units to private supply.
1898	507,830	192,712	183,122
1899	714,504	309,175	232,209
1900	842,490	362,994	290,370
1901	1,286,558	514,391	365,882 and to traction 90,060

The prices range from 6d., 5½d., and 4d. down to 3d. and 2d. per unit, with a rate of 1·9d. for the energy sold to the tramways.

Revenue Statement.

	1900. Gross.	1900. Per unit.	1901. Gross.	1901. Per unit.	Inc.
Sale of energy	£9,979	3·66d.	£13,027	3·22d.	—·44d.
Meter rents	6	·00d.	7	·00d.	·00d.
Sale of old materials, &c. ..	101	·04d.	48	·01d.	—·03d.
Sundry fees, &c.	—	—	—	—	—
Gross revenue ...	£10,086	3·70d.	£13,082	3·23d.	—·47d.

The revenue per unit from energy sold has fallen by nearly ½d., but owing to the increase in output of 316,969 units the total revenue has gone up by £2,996 to £13,082. Owing to the coal bill being nearly halved, and a reduction of over ½d. in the wages per unit, together with sundry smaller economies, the expenditure has only increased by about £400; the works costs falling to under 1½d. and the total cost to just under 2d. per unit, the latter being an improvement exceeding ½d. per unit.

Cost of Production.

	1900. Gross.	1900. Per unit.	1901. Gross.	1901. Per unit.	Inc.
Coal	£3,411	1·25d.	£2,668	·66d.	—·59d.
Oil, waste, water, and engine room stores.	416	·15d.	467	·11d.	—·04d.
Salaries and wages incurred in generation and distribution and attending public lamps.	1,960	·72d.	2,386	·59d.	—·13d.
Repairs and maintenance of buildings, engines, dynamos, boilers, &c., and renewals of street lamps.	939	·35d.	1,399	·35d.	·00d.
Works costs	£6,726	2·47d.	£6,920	1·71d.	—·76d.
Rent, rates and taxes ..	146	·05d.	205	·05d.	·00d.
Management expenses, salaries of managing engineer, secretary, clerks, &c.	510	·19d.	607	·15d.	—·04d.
General establishment charges, stationery and printing, law charges and insurance.	226	·08d.	275	·07d.	—·01d.
Other expenses	—	—	—	—	—
Total costs ...	£7,608	2·79d.	£8,007	1·98d.	—·81d.

The gross profit is more by £2,597 than in 1900, and of this the financial charges absorb only £1,750; the difference of £847 has enabled the loss to be reduced from £3,638 to £2,791. The general balance-sheet shows that the "balance at debit of the net revenue account" is £13,423, or nearly 10 per cent. upon the total capital expenditure on the undertaking.

Profit Statement.

	1900.	1901.
Interest on loans	£3,888	£4,737
Sinking fund for repayments	2,228	3,129
Net profit carried forward	—3,638	—2,791
Gross profit	£2,478	£5,075

CITY NOTES.

The Johnson-Lundell Co.

The directors' report of the Johnson-Lundell Electric Traction Co., Ltd., for the period from May 1st, 1901, to June 30th, 1902, presented to the shareholders at their meeting on December 22nd last, is the most depressing one which we have seen of late in any electrical enterprise, and is not what might have been expected in the second year of the existence of a company started under such auspices, and with apparently such reasonable prospects of success as was the Johnson-Lundell Co.

The directors recognise that the financial results are "disappointing"—a word that does not err on the side of severity—and then proceed to give some explanations:—The greater part of the expenditure was incurred in developing and adapting the inventions acquired by the company, none of which were in form to be commercially applied in this country, where, unfortunately, there is no demand for the type of machine which had been in practical use in America for automobile or motor-car service; the demand here being for tramway and railway motors, the company has been directing its efforts to the practical adaptation of its inventions thereto. The first trial—at Blackburn—for tramway work was made with equipment manufactured in America. This trial demonstrated the soundness of the theory of the invention, but disclosed a serious oversight in practice. The error was of a fundamental character, and the entire work had to be done over again. Further apparatus was completed and tested at Newcastle, and was reported upon to the board as being highly successful, and constituting an important step in advance in electric traction methods. Orders have been placed with German and French manufacturers, with a view to having the apparatus tried on a commercial scale at the earliest date. The delay in arriving at the present stage of development is explained by the company having no works of its own. For the same reason the company is dependent upon other makers for the manufacture of apparatus with which it has been competing for contract work, and has been compelled to meet the present keen competition by abandoning all intermediate profit. In view of the adverse conditions, it has been thought best to limit the company's operations to a commercial demonstration of the value of its motor system, the sale of foreign patents and the receipt of royalties. The staff has been greatly reduced, and the directors take no fees.

The balance-sheet shows that there is an issued capital of £220,000, but as a great part of this is represented by shares issued to vendors, and is therefore the subject of cross entries, we will limit our analysis to cash items. £120,000 has been called up on 40,000 shares, £10,000 has been paid in advance of calls, and calls are in arrear to the amount of £8,982 14s. 10d., making £121,017 5s. 2d., to which has to be added an amount of £4,577 3s. 4d. for amounts received as security for application and allotment money remaining unpaid on shares issued, and a further sum of £3,447 7s. 5d. due to sundry creditors. The total cash liabilities are therefore £129,041 15s. 11d. On the asset side are cash payments for patents, £100,000, stamp duty, &c., £3,214 19s. 11d. Existing plant, machinery, and deposit paid on that ordered, electrotypes, leasehold improvements, office furniture, aggregate, £5,290 9s. 11d. Equipments for experimental work, £6,972 15s. 9d., sundry debtors, £954 17s. 5d. Profit and loss adverse balances for 1901 and 1902, £10,788 14s. 7d., and cash in hand, £1,819 18s. 4d.

The profit and loss account shows that salaries, including consulting engineer's remuneration, amount to £4,528 13s. 3d. Travelling expenses are detailed in four items, which amount together to £735 2s. 1d. Rent, office expenses, drawing office materials and blue prints, stationery and books, advertising, printing, postages, telegrams and bank charges amount to £1,132 7s. 10d. Legal, patent attorney's and auditors' fees, £388 12s. 2d., patents, £914 3s., interest, £137 17s. 3d., and sundry expenses, £309 18s. 3d., make up a total expenditure for the 14 months of £8,146 13s. 10d.

The total receipts for the same period are £758 6s. 11d., of which £9 17s. are for transfers, £193 9s. 11d. for commission and £555 for royalties.

At the meeting of the company, held in October, 1901, and reported in our issue of October 4th, the chairman, in reply to questions, stated that the public subscribed only about 7 per cent. of the capital and his own firm held 6,095 shares. The 7 per cent. subscribed by the public represents the greater part of the working capital, and although this has been added to by those more intimately concerned, it is nevertheless remarkable that the business of a company should have been carried on in such a way as to spend £8,000 in earning £700. The pathetic regret that the company had no works of its own will hardly be shared by those who have had experience of manufacturing, and who may be prompted to ask:—If this is the result without a factory, how much would have been sunk with one? We see no reference in the report to negotiations with the vendors. If the £100,000 paid to them was represented by actual cash, it was surely upon the understanding that the inventions purchased were available for immediate exploitation. In accordance with a too prevalent custom, the directors surrender their fees. It would be far preferable for shareholders to recognise that in times of adversity, the directors are entitled to payment, and look for their payment being earned. If in the carrying out of the inventions a fundamental error was made, is not the responsibility upon the vendors or the consulting engineer? But there is no mention of restitution by vendors, and the consulting engineer does not go unpaid.

We are heartily glad that the general public are not large shareholders in the company, but surely any holders not participating as vendors or officials are entitled to some more reasonable explanations than are contained in the report, of the unsatisfactory results attained. In the interests of shareholders generally it ought to be understood that companies with £20,000 working capital are not entitled to fritter away the greater part in expensive management, even if the directors do stifle a certain amount of criticism by surrendering their own fees.

Blackpool Electric Tramways (South) Co.

The report of this company to be presented to the first ordinary meeting of shareholders states that arrangements have been made with the old company under which the present company is completing the construction of the line and its conversion into electric traction, and the work is being pushed on with rapidity. It is hoped the line will be open for traffic next season. When the reconstruction of the line is completed a meeting of the shareholders will be called at which a full report of the company's affairs will be submitted.

Prospectuses.

A prospectus is before the public—the list of subscriptions closes to-day, Friday—offering £185,000, 5 per cent. debenture stock of the Buenos Ayres Electric Tramways Co. (1901). The total length of lines authorised is about 21 miles single track, of which about 5 miles is now open for traffic. During the year ended September last the gross receipts amounted to £15,122. It is expected that the whole system will be completed and opened for traffic by September next, and it is estimated that the net profit will reach £26,325 annually. The prospectus puts the estimated cost per mile, completed and equipped, at £19,524, and gives the receipts per mile run on the 5 miles of line already working, at 12·32d.

The River Plate Electricity Co., Ltd., has been inviting subscriptions for £100,000 5 per cent. debenture stock. The company has been formed to purchase the business lately owned by the River Plate Electric Light and Traction Co., Ltd., and carried on for the past three years by the Receiver of that undertaking under the direction of the Court of Chancery.

Stock Exchange Notices. — The committee has appointed a special settling day as under:—Wednesday, January 14th.—Metropolitan Electric Tramways, Ltd.—314,016 5 per cent. cumulative preference shares of £1 each, fully paid, Nos. 500,001 to 814,016; and 314,016 deferred shares of £1 each, fully paid, Nos. 1,000,001 to 1,314,016; and has ordered the undermentioned securities to be quoted in the Official List:—Metropolitan Electric Tramways, Ltd.—314,016 5 per cent. cumulative preference shares of £1 each, fully paid, Nos. 500,001 to 814,016; and 314,016 deferred shares of £1 each, fully paid, Nos. 1,000,001 to 1,314,016. Power Gas Corporation, Ltd.—66,462 vendors' ordinary shares of £1 each, fully paid, Nos. 1 to 66,462.

Waygood & Otis, Ltd.—The directors have decided to declare an interim dividend at the rate of 6 per cent.

STOCKS AND SHARES.

Wednesday Evening.

Ease in the money market and a return of business to the investment departments of the Stock Exchange, as a whole, are cheerful factors with which to commence the first week of the new year. In the speculative sections of the House the cry is heard that business is still as far away as ever, but for a variety of reasons the capitalists, large and small, are venturing to turn their money once more into Stock Exchange channels. In the world of electrical finance there are a number of points of practical interest just now, which keep the markets well in view of the man with the money.

Great Northern and City Preferred Ordinary shares are steady to good at 8¼ middle. A certain amount of quiet buying has brought the shares into prominence during the past few days, and of course the "private view" of Tuesday last has directed attention to the company's securities. It may be well to repeat that these 4 per cent. shares are of the nominal value of £10 each, and are fully paid. Interest at the rate of 3 per cent. has been distributed during the construction of the line. City and South London stocks, too, enjoy a freer market than usual on account of the imminence of the dividend, which is expected very shortly. The senior stocks of the company are again in demand, the price of the 1901 Preference stock (to which class we have devoted some favourable hints on several occasions), being raised to 126 buyers. Central Londons are quiet, without particular change, and the latest dividend estimates say that 4 per cent. will be paid on all the Ordinary stocks. Shrewd critics maintain that the company will be easily able to earn 5 per cent. when it seriously tackles the question of building over its stations. But the ventilation problem towers above all else.

Metropolitan Consolidated stock has been up to 92 within the past few days, but a slight relapse occurred on some sensible profit taking. District, too, climbed to a fraction over 40, but failed to maintain its best level. The Preference stock is decidedly harder at 79. Waterloo & City remains scarce; a buyer had to pay 97 for it the other day. Such a price appears quite high enough, possibly too high, in view of the quotations for Consols and other gilt-edged descriptions.

Interesting enough is the little issue of £185,000 in 5 per cent. Debenture stock just offered by the Buenos Ayres Electric Tramways Co., Ltd. From the names of those connected with the enterprise, it may be inferred that the undertaking has substantial chances of success, and considering the bagatelle required to pay the annual interest on the Debenture stock, the stock may be regarded as a very fair investment of its kind.

London United Tramways Preference shares and Debenture stock are both quoted *ex* dividend at 11½ and 104½ respectively; British Electric Traction Preference are 12 to 12⅛ in the market, the Ordinary keeping about 12⅞ and the Debenture stock at 125½.

Remarkably active dealings are taking place in National Telephone issues, more particularly as regards the Preferred and Deferred Stocks, both of which are notably strong. Of course the company is doing a good business, and for some reason or other its stocks have been unduly depressed. Recognition of those points has brought quite a little rush of investment orders into the market, with an instantaneous result upon the prices. Other telephone shares are practically unaltered.

Telegraph issues continue to pass through their usual alternations of cold and heat, this week seeing a check to the downfall, and in one or two cases leaving prices substantially better. Not even the Marconigraphic intelligence that a daily newspaper is on the point of being established on an Atlantic liner is able to stop a rising tendency in Anglo-American stocks, while the Eastern varieties maintain their convalescent condition in regard to prices. Western Telegraph have come into request, and, taking it all round, this department is strong, perhaps surprisingly so in view of the booming of all things connected with Marconi other than his company's shares, the price of which is still no better than 2⅝.

Electricity supply shares display no remarkable changes, but the market is a good one. Metropolitans have sharply improved to over 17, and Charing Cross Preference are somewhat harder. It was playfully suggested that the prompt disavowal by the Charing Cross Co. that their system had anything to do with the temporary failure of the electric light in the vicinity of the Bank the other night drew people's attention to the shares. London Preference have been sold at 5⅛, and both kinds of urban shares changed hands about 5. In the provincial list Oxford Electrics were done at 5½ early in the present week, but this little section plods on its retiring way as usual. Bromptons are a fraction harder, and to hark back to Metropolitans, it may be said that dealings have well-nigh ceased, pending the declaration of the long-desired award by the arbitrators.

SHARE LIST OF ELECTRICAL COMPANIES.

TELEGRAPH AND TELEPHONE COMPANIES.

Present Issue.	NAME.	Stock or Share. ‡	Dividends for the last three years. 1899.	1900.	1901.	Closing Quotations Dec. 31st.	Closing Quotations Jan. 7th.	Business done week ended Jan. 7th, 1903. Highest	Lowest
67,100	African Direct Telegraph, 4 % Debs.	100	..	..	..	98 —102	96 —100 xd	..	..
25,000	Amazon Telegraph Co.'s shares, Nos. 1 to 25,000	10	..	..	..	2¼ — 3¼	2¼ — 3¼	..	..
119,700£	Do. do. 5 % Debs., Nos. 1 to 1,950 Red.	100	..	..	..	70 — 80	70 — 80	..	..
788,840	Anglo-American Telegraph	Stock	7½%	3½%	61s.	48 — 51	48 — 51	48½	..
3,105,580	Do. do. do. 6 % Pref.	Stock	6 %	6 %	6 %	89 — 91	90 — 92	91½	90
3,105,580	Do. do. do. Deferred	Stock	£1 7s.	5s. %	2s.	8¼ — 9	8 — 8½	8⅝	8½
44,000	Chili Telephone, Nos. 1 to 44,000	5	4 %	5 %	5 %	4 — 4½	4 — 4½	..	..
13,333,300$	Commercial Cable	$100	8 %	8 %	8 %	170 —180	170 —180	..	..
1,841,209	Do. do. Sterling 500 year 4 % Deb. Stock Red.	Stock	..	..	..	73 — 75 xd	93 — 95 xd	94½	93½
16,000	Cuba Telegraph	10	7 %	4½%	4 %	5 — 6	5 — 6	..	..
6,000	Do. 10 % Pref.	10	..	..	..	12½ — 13½	13 — 14	..	..
12,981	Direct Spanish Telegraph	5	4 %	4 %	4 %	2¼ — 3¼	2¾ — 3¼	..	..
6,000	Do. do. 10 % Cum. Pref.	5	..	..	..	7 — 8	7 — 8	..	..
£60,710£	Direct United States Cable	20	3½%	3½%	3½%	9½ — 10½	9½ — 10½	10⅛	9⅞
92,800£	Direct West India Cable, 4½% Reg. Deb., within Nos. 1 to 1,200, Red.	100	..	..	..	98 —101 xd	98 —101 xd	..	..
4,000,000	Eastern Telegraph, Ord. Stock	Stock	7 %	7 %	7 %	115 —120	115 —120	118½	115½
1,955,565	Do. 8½ % Pref. Stock	100	..	..	..	89 — 92	89 — 92	89	..
1,534,645	Do. 4 % Mort. Deb. Stock Red.	Stock	..	..	..	105 —108	105 —108	106	..
300,000	Eastern Extension, Australasia, and China Telegraph	10	7 %	7 %	7 %	10 — 11	10½ — 11½	11¼	10½
320,000£	Do. 4 % Deb. Stock	Stock	..	..	..	107 —110	107 —110	..	..
300,000	Eastern & South African Tele., 4% Mt. Db., Nos. 1 to 3,000, red. 1909	100	5¼%	..	..	99 —102	99 —102	100¼	100¼
200,000£	Do. do. 4 % Reg. Mort. Debs. (Mauritius Sub.) 1 to 8,000	25	..	..	..	99 —102	99 —102 %	..	..
180,227	Globe Telegraph and Trust	10	5¼%	5¼%	5¼%	9 — 9½	8½ — 9	8⅞	8½
180,042	Do. do. 6 % Pref.	10	..	..	..	13 — 13½	13 — 13½	13⅛	12⅞
150,000	Great Northern Telegraph, of Copenhagen	10	12½%	15 %	15 %	26 — 27	25 — 26	25⅜	..
66,300£	Halifax and Bermudas Cable, 4½ % 1st Mort. Debs., within Nos. 1 to 1,200, Red.	100	..	..	..	100 —103	98 —101 xd	..	..
17,000	Indo-European Telegraph	25	10 %	10 %	10 %	39 — 43	38 — 42	..	..
100,000£	London Platino-Brazilian Telegraph, 6 % Debs.	100	..	..	..	101 —105	101 —105	..	..
72,680	Montevideo Telephone, Ltd., Ord. Nos. 1 to 72,680	1	2½%	..	..	¼ — ½	¼ — ½	..	..
86,492	Do. do. 5 % Pref., Nos. 1 to 86,492	1	5 %	..	..	¾ — 1	¾ — 1	..	..
1,983,333	National Telephone, Pref. Stock	100	5 %	5 %	5 %	94 — 96	95 — 97	96⅜	94½
1,966,667	Do. do. Def. Stock	100	..	60	64 xd	66 — 68	72 — 74	73½	69
15,000	Do. do. 6 % Cum. 1st Pref.	10	6 %	6 %	6 %	12½ — 13½	12½ — 13½	13¼	13½
15,000	Do. do. 6 % Cum. 2nd Pref.	10	6 %	6 %	6 %	11½ — 12½	12 — 13	12½	12½
250,000	Do. do. 5 % Non-cum. 3rd. Pref., 1 to 250,000	5	5 %	5 %	5 %	5⅜ — 5⅝	5½ — 5⅝	5⅝	..
2,000,000£	Do. do. 3½ % Deb. Stock Red.	Stock	3½%	3½%	3½%	93 — 96 xd	98 — 96 xd	95	94½
600,000	Do. do. 4 % Deb. Stock Red.	100	..	4 %	4 %	99 —103 xd	101 —105	100	..
171,504	Oriental Telephone and Elec. Nos. 1 to 171,504, fully paid	1	5 %	6 %	6 %	¾ — 1	¾ — 1	..	..
100,000£	Pacific and European Tel., 4 % Guar. Debs., 1 to 1,000	100	..	..	..	97 —100 xd	97 —100	..	..
11,839	Reuter's	8	5 %	5 %	5 %	6½ — 7½	6½ — 7½	..	..
3,303	Submarine Cables Trust	Cert.	..	..	..	110 —120	110 —120	..	..
58,000	United River Plate Telephone	5	7 %	7 %	7 %	4½ — 5½ xd	5 — 5½ xd	5½	..
40,000	Do. do. 5 % Cum. Pref., Nos. 1 to 40,000	5	..	..	..	4½ — 5 xd	4½ — 5 xd	..	..
179,947£	Do. do. 5 % Debs.	Stock	..	..	..	100 —103 xd	100 —103 xd	..	..
15,609	West African Telegraph, Shares	10	..	..	..	3 — 4	3 — 4	3	..
30,008	West Coast of America, Nos. 1 to 30,000 and 53,001 to 53,008	2½	..	..	..	0 — ¼	0 — ¼	..	..
150,000£	Do. do. 4% Debs., 1 to 1,500 guar. by Bras. Sub. Tel.	100	..	..	..	98 —101	96 — 99 xd	..	..
267,930	Western Telegraph, Ltd., Nos. 1 to 207,930	10	7 %	7 %	7 %	11 — 11½	11 — 11½	11⅞	11⅞
75,000£	Do. do. 5 % Debs. 2nd series, 1906	100	..	..	..	100 —103 xd	100 —103 xd	..	..
400,000	Do. do. 4 % Deb. Stock Red.	100	..	..	..	97 —100 xd	97 —100 xd	..	..
88,321	West India and Panama Telegraph	10	5%	2%	..	⅝ — ¾	⅝ — ¾	..	..
34,563	Do. do. do. 6 % Cum. 1st Pref.	10	..	..	..	1⅛ — 1⅜	1⅛ — 1⅜	5	4⅞
4,669	Do. do. do. 6 % Cum. 2nd Pref.	10	..	..	..	5⅛ — 5½	5⅛ — 5½	..	..
80,000£	Do. do. do. 5 % Debs., Nos. 1 to 1,800	100	..	..	..	3 — 4	3 — 4	..	..
						100 103	98 —101 xd	..	..

ELECTRICAL RAILWAY, MANUFACTURING AND INDUSTRIAL COMPANIES.

20,000	British Aluminium 7 % Cum. Pref.	10	..	5½%	..	3 — 4	3 — 4	..	..
300,000£	Do. do. 5 % 1st Mort. Deb. Stock Red.	Stock	..	..	..	75 — 80	75 — 80	..	..
100,000	British Electric Traction	10	8 %	9 %	9 %	12½ — 13	12¾ — 13½	12⅞	12¾
100,000	Do. do. 6 % Cum. Pref.	10	..	..	..	11½ — 12½	11¾ — 12½	12⅛	11¾
600,000£	Do. do. 5 % Perpetual Debenture Stock	Stock	..	..	..	124 —127	124 —127	126	124½
100,000	British Insulated Wire Ord.	5	20 %	15 %	10 %	7½ — 8	7½ — 8	..	..
100,000	Do. do. 6 % Cum. Pref.	5	..	..	..	5½ — 6	5½ — 6	..	..
50,000	Do. do. 4½ % 1st Mort. Deb. Red.	100	..	..	..	103 —106 xd	105 —108	..	..
50,000	¶Browett, Lindley & Co. (1899), Ord.	£1	..	8 %	..	12/6 to 13/6	12/6 to 13/6	..	..
50,000	¶ Do. do. 6 % Cum. Pref.	£1	..	6 %	..	16/6 to 17s.	16/6 to 17s.	..	..
105,731	Brush Electrical Engineering, Ord., 1 to 105,731	2	5%	5 %	Nil	¾ — 1¼	¾ — 1¼	..	..
150,000	Do. do. Non-cum. 6 % Pref.	2	6 %	6 %	3 %	1 — 1½	1 — 1½	..	..
125,000£	Do. do. 4½ % Perp. Deb. Stock	Stock	..	..	..	100 —103	100 —103	..	..
125,000£	Do. do. 4½ % Perp. 2nd Deb. Stock	Stock	..	..	..	98 — 98	98 — 98	..	..
35,000	Callender's Cable Construction shares	5	15 %	15 %	20 %	14 — 15	14 — 15	14⅜	..
40,000	Do. do. do. 5 % Cum. Pref.	5	..	..	..	5¼ — 6 xd	5¼ — 6 xd	5⅜	..
90,000£	Do. do. do. 4½ % 1st Mort. Deb. Stock Red.	Stock	..	..	..	107 —110	108 —112 xd	..	..
1,860,014	Central London Railway, Ord. Stock	Stock	..	..	4 %	105 —108	107 —110	109½	109½
494,093	Do. do. 4 % Pref. Stock	Stock	..	..	4 %	108 —111	105 —108	..	..
494,993	Do. do. Def. do.	Stock	..	..	4 %	106 —109	108 —112	..	..
1,830,000	City and South London Railway	Stock	1½%	1½%	2 %	75½ — 76½	75½ — 76½	76⅛	75
85,000	Crompton & Co., Nos. 1 to 85,000	3	7½%	8 %	7½%	2½ — 3	2½ — 3	2⅝	..
100,000£	Do. 5 % 1st Mort. Reg. Debs., 1 to 900 of £100, and 901 to 11,000 of £50 red.	..	..	..	..	101 —106 %	100—105% xd	..	..
99,261	Edison & Swan United Elec. Light, "A" shares, £3 paid, 1 to 99,261	5	6 %	2½%	..	⅞ — 1	⅞ — 1	..	..
17,139	Do. do. "A" shares, 01—017,139	5	6 %	2½%	..	1½ — 2¼	1½ — 2¼	..	..
344,028£	Do. do. 4 % Deb. Stock Red.	100	..	..	..	74 — 78	73 — 77 xd	..	..
100,000£	Do. do. 5 % 2nd Deb. Stock Prov. Certs. all pd.	100	..	..	..	77 — 82	77 — 82	..	..
112,100	Electric Construction, 1 to 112,100	2	6 %	6 %	6 %	1½ — 1⅝	1½ — 1⅝	..	..
31,390	Do. do. 7 % Cum. Pref., 1 to 31,390	2	..	..	..	2¼ — 2⅜	2¼ — 2⅜	..	..
182,500£	Do. do. 4 % Perp. 1st Mort. Deb. Stock	Stock	..	..	..	99 —102	99 —102	..	..
25,000	General Electric Co. (1900), 5 % Cum. Pref.	10	..	5 %	5 %	10 — 10½ xd	10 — 10½ xd	10½	10
200,000	Do. do. 4 % Mort. Deb.	Stock	..	..	..	99 —102	100 —103	..	..
35,000	Henley's (W. T.) Telegraph Works, Ord.	5	15 %	20 %	20 %	16½ — 17½	16½ — 17½	17	16½
35,000	Do. do. 4½ % Pref.	5	4½%	4½%	..	5½ — 5⅝	5½ — 5⅝	..	..
48,050	Do. do. 4½ Mort. Deb. Stock	Stock	..	..	..	109 —113	109 —113	..	..
50,000	India-Rubber, Gutta-Percha & Telegraph Works	10	10 %	10 %	10 %	20 — 21	19½ — 20½ xd	..	..
300,000£	Do. do. do. 4 % 1st Mort. Deb.	100	..	..	..	100 —103	101 —104	..	..
37,500	†Liverpool Overhead Railway, Ord.	10	3½%	3½%	1½%	5⅜ — 5⅞	5⅜ — 5⅞	..	..
10,000	† Do. do. Pref. £10 paid	10	5 %	..	..	9½ — 10½	9½ — 10½	..	..
7,500	Parker (Thomas), Ltd., Ord., Nos. 1 to 7,500	10	..	..	..	14⅜ — 15½	14⅜ — 15½	..	..
	§Rosling & Fynn 6 % Cum. Pref.	£1	..	6 %	..	.. — ..	19/0 to 20/0	..	..
37,350	Telegraph Construction and Maintenance	12	15 %	17½%	20 %	37 — 40	37 — 40	39½	38
150,000£	Do. do. 4 % Deb. Bds., Nos. 1 to 1,500 Red. 1909	100	..	..	..	102 —105	101 —104 xd	..	..
540,000£	Waterloo & City Railway, Ord. Stock	100	3 %	3 %	3 %	94 — 97	94 — 97	97	..

† Quotations on Liverpool Stock Exchange.
§ From Bradford Share List.
‡ Unless otherwise stated all shares are fully paid.
¶ From Manchester Share List.

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED.

Consolidated Telephone Construction and Maintenance, ⅞—1.
National Electric Free Wiring, ¾—1.
Oldham, Ashton, and Hyde Electric (£10 pd.), Ord., 13—14.
Do. do. Pref (£10 pd.), 10—11.

Bank rate of discount 4 per cent. (October 2nd, 1902).

SHARE LIST OF ELECTRICAL COMPANIES (*continued*).—ELECTRICITY SUPPLY COMPANIES.

Present issue.	NAME.	Stock or Share.	Dividends for the last three years. 1899.	1900.	1901.	Closing Quotations Dec. 31st.	Closing Quotations Jan. 7th.	Business done week ended Jan. 7th, 1903. Highest.	Lowest.
100,000	Blackheath and Greenwich Dist. Electric Light, Ord...	‡ 1	..	..	..	⅜— ⅝	⅜— ⅝	..	..
100,000	Do. 4½% 1st Deb. Stock, Prov. Certs. ..	100	..	..	..	110 —113	110 —113	..	..
20,000	Brompton & Kensington Electric Light Sup., Ord., 1 to 20,000 ..	5	6 %	6 %	8 %	10 — 10¼	10½— 10⅝	..	..
20,000	Do. do. 7 % Cum. Pref. ..	5	..	..	..	10 — 10¼	10 — 10¼	..	..
50,000	Charing Cross and Strand Electricity Supply	5	9 %	9 %	10 %	9½— 9⅝	9½— 9⅝	..	..
70,000	Do. do. do. 4½% Cum. Pref. ..	5	..	..	..	5⅜— 5⅝	5⅜— 5⅝	15⅛	..
40,000	Do. do. "City Undertaking" 4½% Cum. Pref. ..	5	..	..	..	4¾— 5¼ xd	4¾— 5¼ xd	..	..
250,000	Do. do. 4 % Deb. Stock Red.	100	..	..	..	103 —105 xd	103 —105	104½	..
44,436	*Chelsea Electricity Supply, Ord.	5	6 %	5½%	4 %	5⅛— 5⅜	5⅛— 5⅜	..	..
150,000‡	Do. do. % Deb. Stock Red.	Stock	..	..	..	108 —111 xd	108 —111 xd	..	..
70,595	City of London Electric Lighting, Ord. 40,001—110,595	10	4 %	0 %	5 %	10½— 11	10½— 11	10⅛	..
40,000	Do. 6 % Cum. Pref., 1 to 40,000	10	6 %	6 %	..	13 — 14	13 — 14	13½	..
400,000‡	Do. 5 % Deb. Stock, Scrip. (iss. at 115) all paid	..	..	..	..	122 —12 xd	122 —127 xd	..	..
300,000	Do. 4½% 2nd Deb. Stock, Prov. Certs., all paid	100	..	..	..	102 —105 xd	102 —105 xd	..	..
40,000	County of London & Brush Prov. Electric Lighting, Ord. 1—40,000.	10	4 %	4 %	4 %	8¾— 9⅛	8¾— 9⅛	..	..
20,000	Do. do. do. 6 % Pref., 40,001—60,000.	10	6 %	6 %	..	12 — 13	12 — 13	..	..
400,000‡	Do. do. 4½% Deb. Stock, Prov. Certs. (all paid) Red ..	..	..	..	..	107 —110 xd	109 —112	..	..
50,000	Edmundson's Electric Corporation, Ord. Shares	5	6 %	7 %	7 %	6½— 6⅞	6½— 7	6⅞	..
30,000	Do. do. 6 % Cum. Pref.	..	..	..	..	6 — 6½	6 — 6½	6⅛	6
140,000	Do. do. 4½% 1st Mort. Deb. Stock ..	100	..	..	..	107 —110	107 —110	..	..
21,000	Kensington and Knightsbridge Electric, Ord.	5	11 %	12 %	10 %	10 — 11	10 — 11	..	..
90,000	Do. do. do. 4 % Debenture Stock ..	Stock	..	..	..	101 —104	101 —104	..	..
110,000	ondon Electric Supply Corporation, Limited, Ord.	3	..	..	..	1⅞— 2⅛	1⅞— 2⅛	..	..
49,840	Do. do. do. 6 % Pref.	5	..	..	..	5 — 5⅛	5 — 5⅛	5⅛	5⅛
250,000‡	Do. do. do. 4 % 1st Mort. Deb. Stock Red	Stock	..	..	..	96 — 99	96 — 98	..	..
100,000	Metropolitan Electric Supply, 1 to 100,000	10	5 %	6 %	6⅛%	15½— 16⅛	16½— 17⅛	17	16⅞
220,000‡	Do. do. 4½% 1st Mort. Deb. Stock	..	..	..	..	107 —112 xd	107 —112 xd	..	..
250,000‡	Do. do. 3½% Mort. Deb. Stock Red	Stock	..	..	..	99 —102	98 —101 xd	..	..
10,852	Notting Hill Electric Lighting	10	7 %	7 %	6 %	14½— 15½	14½— 15½	..	..
40,000	St. James' and Pall Mall Electric Light, Ord.	5	14⅓%	14⅓%	14⅓%	14⅜— 15⅝	14⅜— 15⅝	..	..
20,000	Do. do. do. 7 % Pref. 20,081 to 40,080	5	7 %	7 %	7 %	8¾— 9⅛	8¾— 9⅛	..	..
150,000‡	Do. do. do. 3½% Deb. Stock Red ..	100	..	..	..	98 —101	97 —100 xd	..	..
12,000	Smithfield Markets Electric Supply, Ord.	5	..	..	..	1⅞— 2⅛	1⅞— 2⅛	..	..
50,000‡	Do. do. 4% Deb.	100	..	..	..	80 — 90	80 — 90	..	..
65,000	South London Electricity Supply, Ord.	5	..	..	..	3 — 3⅛	3 — 3⅛	..	..
30,000	Urban Electric Supply, Ord.	5	..	..	..	3⅞— 4⅛	4⅛— 5⅛	4⅛	..
30,000	Do. do. 5 % Cum. Pref.	5	..	..	..	3⅞— 4⅛	4⅛— 5⅛	5	..
110,000	Westminster Electric Supply, Ord.	5	13 %	10⅝%	10⅝%	11 — 12	11 — 12	11⅛	..
28,141	Do. do. 5 % Cum. Pref.	5	..	..	..	6 — 6½	6¼— 6⅝	..	..

* Subject to Founders Shares. ‡ Unless otherwise stated all shares are fully paid.

MARKET QUOTATIONS, Wednesday, January 7th,

	CHEMICALS, &c.		This week.	Last week.	Inc. or Dec.
a	Acid, Hydrochloric	per cwt.	5/-	5/-	..
a	,, Nitric	per cwt.	22/-	22/-	..
a	,, Oxalic	per cwt.	32/-	32/-	..
a	,, Sulphuric	per cwt.	5/6	5/6	..
a	Ammoniac, Sal	per cwt.	42/-	42/-	..
a	Ammonia, Muriate (crystal) ..	per ton	£33 10	£33 10	..
a	,, ,, ...	per ton	£30	£30	..
a	Bleaching powder	per ton	£4 10	£4 10	..
a	Bisulphide of Carbon	per ton	£15	£15	..
a	Borax	per ton	£13	£13	..
a	Benzole (90 %)	per gal.	7/-	7/-	..
a	,, (50/90 %)	per gal.	5/6	5/6	..
a	Copper Sulphate	per ton	£17 10	£17 10	..
a	Lead, Nitrate	per ton	£24	£24	..
a	,, White Sugar	per ton	£31	£31	..
a	,, Peroxide	per ton	£27 10	£27 10	..
a	Methylated Spirit	per gal.	2/6	2/6	..
a	Naphtha, Solvent (90% at 160° C).	per gal.	5/6	5/6	..
a	Potash, Bichromate, in casks ..	per lb.	3d.	3d.	..
a	,, Caustic (75/80%)	per ton	£24	£24	..
a	,, Bisulphate	per ton	£35	£35	..
a	Shellac	per cwt.	130/-	130/-	..
a	Sulphate of Magnesia	per ton	£4 10	£4 10	..
a	Sulphur, Sublimed Flowers ..	per ton	£6 5	£6 5	..
a	,, Recovered	per ton	£5 10	£5 10	..
a	,, Lump	per ton	£5	£5	..
a	Soda. Caustic (white 70 %) ..	per ton	£10 15	£10 15	..
a	,, Crystals	per ton	£3	£3	..
a	,, Bichromate, casks	per lb.	2¼d.	2¼d.	..
	METALS, &c.				
b	Aluminium Ingots, in ton lots ..	per ton	£148	£148	..
b	,, Wire, in ton lots ..	per ton	£224	£224	..
b	,, Sheet, in ton lots ..	per ton	£191	£191	..
p	Babbitt's metal ingots	per ton	£40 to £130	£40 to £130	..
c	Brass (rolled metal 2" to 12") basis	per lb.	6¼d.	6¼d.	¼d. inc.
c	,, Tube (brazed)	per lb.	8¼d.	8¼d.	..
c	,, ,, (solid drawn) ..	per lb.	6¾d.	6¾d.	..
c	,, Wire, basis	per lb.	6¾d.	6½d.	¼d. inc.
c	Copper Tubes (brazed)	per lb.	8¾d.	8¾d.	..
c	,, ,, (solid drawn) ..	per lb.	9d.	9d.	..
g	Copper Bars (best selected ..	per ton	£65	£65	..

	METALS, &c. (*continued*).		This week.	Last week.	Inc. or Dec.
g	Copper Sheet	per ton	£65	£65	..
g	,, Rod	per ton	£65	£65	..
e	,, (Electrolytic) Bars ..	per ton	£55	£55	..
e	,, ,, Sheets ..	per ton	£73	£73	..
e	,, ,, Rod ..	per ton	£61	£61	..
e	,, ,, H.C. Wire	per lb.	7d.	7d.	..
f	Ebonite Rod	per lb.	3/-	3/-	..
f	,, Sheet	per lb.	5/-	5/-	..
n	German Silver Wire	per lb.	1/4½	1/4½	..
h	Gutta-percha fine	per lb.	8/-	8/-	..
h	India-rubber, Para fine	per lb.	3/8 to 3/10½	3/4½ to 3/7½	inc.
i	Iron, Charcoal Sheets	per ton	£18	£18	..
i	,, Pig (Cleveland warrants)	per ton	48/-	47/6	6d. inc.
i	,, Forgings, according to size	per ton	From £11	From £11	..
i	,, Scrap, heavy	per ton	47/6 to 50/-	47/6 to 50/-	..
i	,, Wire, galvanised No. 8 ..	per ton	£9 15	£9 15	..
g	Lead, English Ingot	per ton	£11 5 to £11 7 6	£11 to £11 2 6	5s. inc.
g	,, ,, Sheet	per ton	£13	£13	..
m	Manganin Wire No. 28	per lb.	8/-	8/-	..
g	Mercury	per bot.	£8 15	£8 15	..
d	Mica (in: ginal cases) small ..	per lb.	3d. to 9d.	3d. to 9d.	..
d	,, ,, ,, medium	per lb.	1/9 to 2/9	1/9 to 2/9	..
d	,, ,, ,, large ..	per lb.	3/3 to 7/3	3/3 to 7/3	..
p	Phosphor Bronze, plain castings	per lb.	11½d. to 1/2	11½d. to 1/2	..
p	,, rolled bars & rods	per lb.	1/- to 1/3	1/- to 1/3	..
p	,, ,, strip & sheet	per lb.	From 1/2	From 1/2	..
o	Platinum	per oz.	£4	£4	..
p	Silicium Bronze Wire	per lb.	9d. to 1/-	9d. to 1/-	..
i	Stee., Magnet, acc'd'g to desc'p'n	per ton	£58	£58	..
i	,, ,, in bars		From £15 to £40		..
g	Tin, Block	per ton	£126 to £127	£118 to £119	£8 inc.
g	,, Foil	per lb.	1/6	1/6	..
n	,, Wire, Nos. 1 to 16	per lb.	1/7	1/6½	¼d. inc.
p	White Anti-friction Metals— "White Ant" brand ..	per ton	£36 to £60	£36 to £60	..
j	Yarns, 2/10s Grey Cotton, on sp'ls	per lb.	7d.	7d.	..
j	,, 6 lea. Flax	per lb.	5¾d.	5¾d.	..
j	,, 3 ply 10 lbs. Russian ..	per lb.	4½d.	4½d.	..
j	,, 10 lbs. Russian, single ..	per lb.	4¼d.	4¼d.	..
j	,, 180 lbs. Jute rove ..	per ton	£11	£11 11	11s. dec.
k	Zinc, Sh't (Vieille Montagne bnd.)	per ton	£23	£23	..

Quotations supplied by
a Messrs. G. Boor & Co.
b The British Aluminium Co., Ltd.
c Messrs. Thos. Bolton & Sons., Ltd.
d Messrs. F. Wiggins & Sons.
e Messrs. Frederick Smith & Co.

Quotations supplied by
f India-Rubber, G.P. and Teleg. Works
g Messrs. James & Shakspeare. [Co., Ltd.
h Messrs. Edward Till & Co.
i Messrs. Bolling & Lowe.
j Messrs. Walter H. Hindley & Co., Ltd.

Quotations supplied by
k Messrs. Morris Ashby, Limited.
m Messrs. W. T. Glover & Co., Ltd.
n Messrs. P. Ormiston & Sons.
o Messrs. Johnson, Matthey & Co., Ltd.
p The Phosphor Bronze Company Ltd.

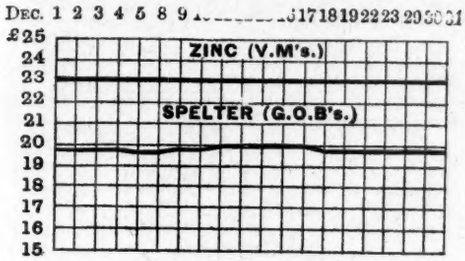
TRAFFIC RECEIPTS.

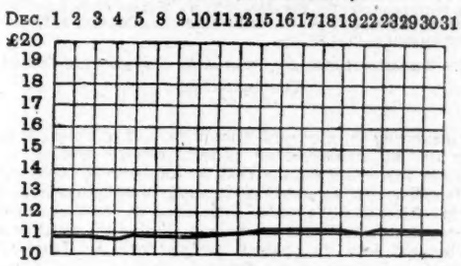
Company.	Week ending	Receipts for the week. Am't.	Inc. or dec.*	Total to date. Am't.	Inc. or dec.*	Miles open. This year.	Last year.
		£	£	£	£		
Blackburn Corp. Trys. ..	Jan. 3	831	+ 65	31,110	+ 4,272	12¼	13¼
Blackpool and Fleetwood	,, 3	209	+ 12	29,959	— 63	7½	7½
Bristol Trys. & Car. Co.	,, 2	4,658	+354	—	—	28	28
British Elec. Trac. Co.:—							
Barnsley	Dec. 26	209	—	1,218	—	—	—
Devonport	,, 26	467	+ 30	22,046	+ 1,202	5	5
Dudley—Stourbridge..	,, 26	889	+158	38,896	+ 4,894	18½	18½
Gateshead	,, 26	1,041	+354	39,807	+ 8,316	10½	9½
Gravesend—Northfleet	,, 26	273	—	4,261	—	3½	—
Greenock—Pt. Glasgow	,, 26	455	+ 77	25,538	+13,512	7½	7½
Hartlepool	,, 26	279	+ 54	12,942	+ 1,351	6¾	4½
Kidderminster	,, 26	129	+ 9	6,304	+ 69	4½	4½
Merthyr	,, 26	274	— 17	10,222	— 1,797	8	8
Middleton	,, 26	266	—	11,278	—	8½	—
Oldham—Ashton ..	,, 26	561	+ 91	27,411	+ 1,734	8	8
Poole	,, 26	318	+ 87	13,216	+ 122	3½	3½
Potteries	,, 26	1,945	+369	78,292	+ 5,495	28½	28½
Rotherham	,, 26	37	+ 10	1,988	+ 643	—	—
B.E.T. Co. (*continued*)—							
Southport	Dec. 26	225	+111	13,141	+ 4,865	5½	5½
South Staffordshire..	,, 26	890	— 82	38,550	— 1,623	21½	22½
Swansea	,, 26	649	+ 36	24,506	+ 1,595	5½	5½
Taunton	,, 26	66	— 14	3,273	— 376	1½	—
Tynemouth	,, 26	251	+ 69	14,915	+ 2,204	3½	3½
Weston-super-Mare..	,, 24	28	—	5,588	—	2½	—
Wolverhampton Dist.	,, 26	467	+328	11,842	+ 7,757	10½	2½
Central London Railway	Jan. 3	6,683	+575	b,683	+ 575	6	6
City and S. London Ry.	,, 4	3,436	+260	3,436	+ 260	6½	6½
Doncaster Corp. Trys. ..		—	—	—	—	5½	—
Dover Corporation Trys.	,, 3	189	— 4	—	—	3	3
Dublin United Trys. ..	,, 3	4,179	—150	126,121	+ 3,540	46	46
East Ham Tramways ..	,, 3	473	+148	14,042	+ 8,167	5	4½
Glasgow Corp. Trys. ..	,, 3	14,188	+1,172	382,166	+ 571	62	50½
Liverpool Overhead Ry.	,, 4	1,496	+ 94	1,496	+ 94	6½	6½
Newcastle Corp. Trys. ..	,, 3	2,239	—	—	—	35	—
Sunderland Corp. Trys.	,, 4	1,217	— 60	—	—	17½	17½

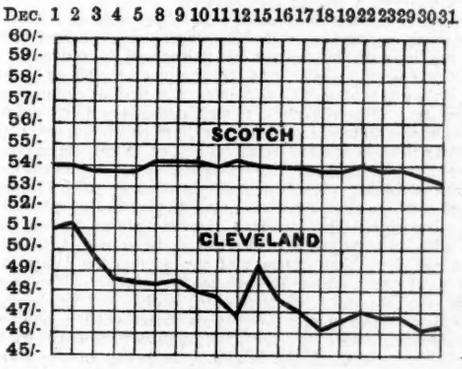
* Compared with the corresponding period of 1901.

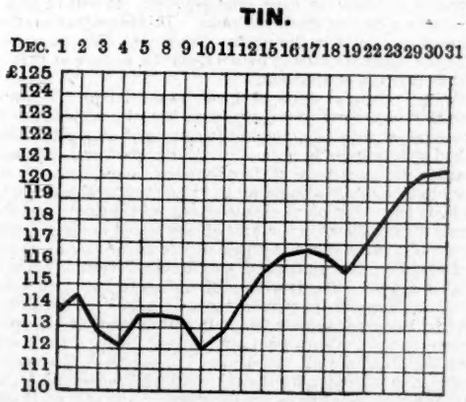
METAL MARKET.

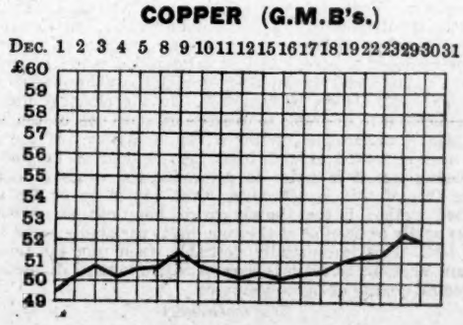
Fluctuations in December, 1902.











INSTITUTION OF ELECTRICAL ENGINEERS.

THE PHOTOMETRY OF ELECTRIC LAMPS.

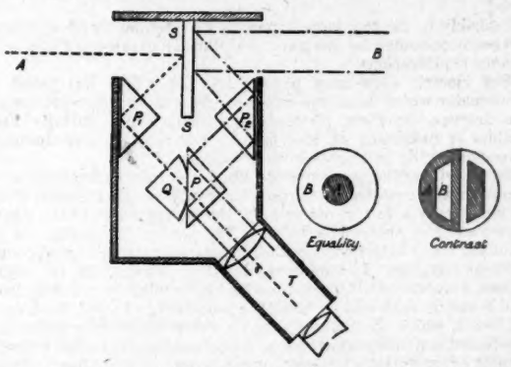
By Dr. J. A. Fleming, M.A., F.R.S., Member, Professor of Electrical Engineering in University College, London.

(*Abstract of Paper read December 11th, 1902.*)

(*Continued from page 40.*)

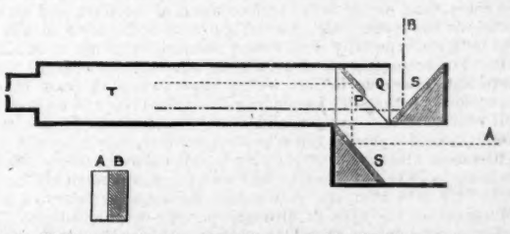
II.—Photometric Processes.

Generally speaking, a photometric measurement consists in comparing together the brightness of two white surfaces, one illuminated solely by the light under test, and the other by a standard light, and adjusting the distance of the lights until an equality in brightness or illumination is secured. A typical and simple form of photometer, therefore, is the Ritchie wedge, in which two adjacent sides of a white prism inclined at equal angles to the incident rays serve as the two surfaces which are differently illuminated. Whatever may be the exact nature of the arrangement for creating these two contiguous surfaces illuminated by different sources of light, it appears to be an essential condition for sensitiveness that they shall not be separated by any dark or bright space not illuminated wholly by one light or the other. Hence, whatever form a photometer may take, it must be one in which this accurate juxtaposition of the two surfaces to be compared can be secured. Another condition is, that the illuminated surfaces must be perfectly white. There is a vast difference between surfaces in regard to whiteness, which are all called white. A suitable white surface for photometry can be obtained by compressing magnesium carbonate or barium sulphate into slabs. In the Lummer-Brodhun photometer, such a white magnesia slab is illuminated on its two opposite sides by the two lights to be compared (see fig. 3). By the means of two totally reflecting prisms, P_1, P_2, the diffused light from the two sides is sent through a compound glass prism, P Q, consisting of two right-angle prisms placed base to base. One of these prisms has portions of its hypothenuse surface removed by sand-blasting, so as to be at a lower level than the rest, and the two right-angle prisms have their hypothenuse surfaces placed together, being faced to come into optical contact where they touch.



S, Magnesia screen; P_1, P_2, Totally reflecting prisms; Q P, Lummer-Brodhun prism; T, Telescope.

Fig. 3.—Lummer-Brodhun Photometer.



P Q, Right-angle prisms; T, Eye-tube; S S, White diffusing screens; A B, Field of view—the two parts illuminated respectively by light A and light B.

Fig. 4.—Total Reflection Photometer (Fleming).

When such a prism is viewed by means of a telescope and an eye-piece in the proper position, we see the field of view divided into two parts, one portion of which is illuminated by the diffused light scattered from one side of the magnesia slab, and the other side by light scattered from the other. By adjusting the distances of the lights, the brightness of these two portions of the field of view can be made to agree. If the lights are heterochromatic, then these two portions of the field of view have different colours as well as different brightness, and the observer has to make a judgment when the two patches agree in brightness without regard to their difference in tint. The author has devised a modification of the Lummer-Brodhun photometer, in which the two lights, A and B,

to be compared are placed one in front and one at the side of the prism box. This form has some advantages for arc lamp testing (see fig. 4).

Some considerations affecting heterochromatic photometry are discussed below, but meanwhile it may be said that there are various methods for reducing the distraction caused by this colour difference in the lights compared. In the old form of Bunsen grease-spot photometry, the difficulty of making an accurate judgment as to the equality in brightness of the two surfaces to be compared was considerable, but the difficulty was obviated to some extent in the form of disc known as the star disc, in which the simple grease spot of Bunsen was replaced by a sheet of tissue paper placed between two discs of thin white cardboard, in both of which a star-shaped opening had been punched out.

Photometers are divided into three principal classes:—

(A) *Intensity photometers*, by means of which a comparison is made between the luminous intensities of two sources of light.

(B) *Illumination photometers*, by means of which we measure the illumination in any locality in *candle-feet* or some similar units.

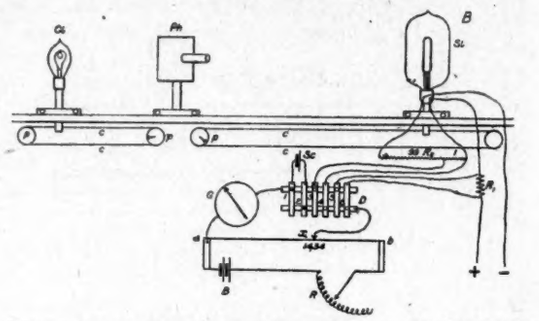
(C) *Spectrophotometers*, in which selected rays from the spectra of two lights are compared in respect of luminous intensity.

The intensity photometers may be classified according to the method adopted for producing two adjacent surfaces or comparing the brightness of the two surfaces illuminated by the lights compared.

Probably by far the largest portion of photometry of late years has been conducted by means of the Bunsen grease-spot disc or its various modifications.

For electric glow-lamp photometry the writer has found no photometer which is on the whole superior to the contrast form of the Lummer-Brodhun photometer, which, when skilfully used, enables a difference of less than ½ per cent. in the luminous intensity of the two lights to be determined.*

In describing the arrangements which the writer's experience has shown to be the most advantageous for glow-lamp photometry, it will be well to say a few words first on the arrangement of the photometer and the photometer room. The general impression in the minds of many electricians is that any room or corner is good enough for a photometer. In numerous electrical laboratories or testing-rooms, a wooden shelf is put up with black velvet curtains in front, and a box at each end to hold the standard lamp and the lamp to be tested, whilst the Bunsen disc or other photometer slides on a graduated bar between the lamps. A photometer of this kind embodies almost every defect a photometer can have. It reproduces, often in an aggravated manner, the defects present in a form of photometer called the Evans closed photometer, long known to be unreliable. The chief source of error in it is that reflection of stray light from the neighbouring velvet or black wood surfaces causes the illumination on the photometer disc to vary *not* according to the law of the inverse square of the distance from the source of light. A photometer consisting of a long box or narrow shelf invariably allows a good deal of light to be reflected at an oblique incidence, even from black velveteen curtains. The whole principle on which intensity photometry is based, is that no light must reach the photometer disc except that coming in straight lines from the two sources. Hence it is essential not to take this for granted in any particular instance, but to verify it. In the next place, such a closed photometer, if used with a flame standard of any kind, invariably gives erroneous measurements because of imperfect ventilation. If a flame standard is to be used at all, the greatest attention must be paid to the temperature and ventilation of the photometer room. For this purpose, it should be at least 8 ft. wide, 8 ft. or 9 ft. high, and 20 ft. in length. Fresh air should be drawn in from the outside by means of a fan, and circulated through the room, but with the avoidance of draughts. If this is not done, and two or three people are in the photometric room employing a flame standard, it will most certainly fall off in luminous intensity by a sensible percentage in a short time, owing to the accumulation of moisture and carbon dioxide in the room. Also the temperature of the room should be kept uniform, especially if electrical measurements are to be made in it. The arrangements of a suitable photometric room for glow-lamp testing are as follows:—The room being at least of the dimensions above stated, should be painted dead black in its interior, well ventilated as described, and kept at a constant temperature. Down the centre should run a wooden railway, consisting of a pair of beams on which can travel easily wooden slabs or tables holding the lamp to be tested, the standard and the photometer, the height being such as to bring the photometer telescope or tube to a level convenient for the eyes of ordinary persons when standing. The arrangements adopted after long experience in the Pender Electrical Laboratory at University College, London, and reproduced in the photometer rooms of the Edison and Swan Electric Lighting Co.'s factory at Ponder's End, at the suggestion of the writer, are as follows:—The photometer employed is the Lummer-Brodhun photometer with contrast prism, and is kept fixed in one position on the railway (see fig. 5). On the left-hand side, carried on a sliding table, is an incandescent lamp, which is called the *comparison lamp*, and by means of appropriate resistances this lamp can be adjusted accurately for voltage and therefore candle-power. The sliding table on the right-hand side is connected to an endless cord moved by a winch, so that the observer at the photometer can move the lamp on this table to or from him. This slab carries a support for the incandescent lamp to be tested, so arranged that the lamp can be placed with its axis in any required direction, and also revolved on its axis by means of a small electric motor. Under the railway are placed the resistances and controlling handles for regulating the current and voltage of the lamp to be tested, and for this purpose, from the socket holding the above lamp, there come two pairs of leads, one the current leads, and the other the potential leads.



Cl, Comparison lamp; Ph., Lummer-Brodhun photometer; *a b*, Potentiometer wire; G, Galvanometer; Sc., Standard cell; R_2, Voltage divided resistance; Sl, Standard lamp; *p p*, Pulleys; *c c*, Endless cords; B, Battery; R, Rheostat; R_1, Series resistance; D, Plug switch.

FIG. 5.—ARRANGEMENTS OF STANDARD PHOTOMETER BENCH AND POTENTIOMETER.

For measuring the electrical quantities, no instrument is so satisfactory as the direct-reading potentiometer. Out of a large experience, the writer can say that no ammeter or voltmeter yet made is sufficiently accurate for electric-lamp photometry. It was with this object that the writer introduced as far back as 1888 the direct-reading potentiometer, set by a Clark cell, which has been since brought into its present perfect form by Lieut.-Colonel Crompton, and those of his firm who have assisted him. The modification which the author then introduced was that of adjusting the current through the potentiometer coils or wire, so that the fall of potential down a unit of length of the wire was equal to one-thousandth or one ten-thousandth of a volt, as determined by comparison with a standard cell. Employing a Crompton potentiometer, readings of the current and voltage of incandescent lamps can be taken quite as quickly in the photometer room as by the use of any ordinary ammeter or voltmeter, and with an accuracy which is far greater. The only point to which attention need be drawn is that the temperature variation of the Clark cell being considerable, it is better to use a Weston cadmium cell, or Helmholtz calomel cell in place of the Clark cell. The operation of making measurements by means of the large bulb standard glow-lamps is as follows:—A standard lamp is selected giving, say, 16 candles at 96 volts in a certain direction. This standard lamp is placed in the testing socket with its axis upright, and set at a distance of 4 ft. from the photometer disc. The distance of the comparison lamp is then varied until the photometric balance is obtained. The standard lamp is then removed from the testing socket and the lamp to be tested placed therein, and its distance varied until a photometric balance is again obtained. From the relative distances of the tested lamp and the standard, the luminous intensity of the former is determined in terms of the latter. The railway bar can, of course, be calibrated to show at once candle-power. It will be seen that this process is a form of *double weighing*. It eliminates the effect of any want of symmetry in the photometer itself. The exact candle-power of the comparison lamp does not matter, as long as it remains constant during the experiment.

In making a series of tests of incandescent lamps, it is desirable to check the setting of the comparison lamp by means of a large bulb standard, at intervals, just as the setting of the potentiometer is checked at intervals by means of the standard cell. In making photometric examinations of incandescent lamps, it is of course necessary to take the candle-power in different directions. In order to eliminate the variation in candle-power which exists in different horizontal directions when the axis of the tested lamp is vertical, a committee of the American Institute of Electrical Engineers recommended that the lamp under test should be revolved on its vertical axis. This is not difficult with stiff filaments, but with the long high-voltage filaments now used there is a risk of breaking the filament, or forcing it against the bulb of the lamp, if the speed of revolution exceeds about two per second, and this is hardly sufficient to eliminate all flickering. In any case, the maximum horizontal and minimum horizontal candle-power should be taken, and also the candle-power in the direction of the axis of the lamp. For certain purposes, it may be necessary to take the mean spherical candle-power. The usual process is to be content with taking the maximum candle-power in a horizontal direction, but since by far the larger number of lamps are hung head downwards, in use this value alone does not give sufficient information as to the performance of the lamp, and the candle-power in the above-stated three directions should always be furnished. In the actual photometric measurements it is desirable to oscillate or move one of the lamps on a plan recommended by Sir W. de W. Abney. If the lamp under test is moved to and from the photometer in gradually diminishing arcs, it is easier to determine the exact position of balance than if this is not done. One advantage of the above described method is that the comparison lamp can be adjusted to work as nearly as possible at the same watts per candle as the lamps under test. This is especially desirable when using the Lummer-Brodhun photometer, as it is very sensitive to small differences in the spectral quality of lights compared.

(To be continued.)

* The Lummer-Brodhun photometer is in reality a very superior form of Bunsen grease-spot photometer

ON ELECTRONS.

By Sir Oliver Lodge, F.R.S., Vice-President.

(Paper read in London, November 27th, 1902.)

(Continued from page 38.)

Conduction in Gases.

We will now leave liquids and proceed to conduction by rarified gases, that is to say, to the phenomena seen in vacuum tubes. If a long glass tube, say a yard long and 2 in. wide, with an electrode at each end, and full of common air, is connected to an induction coil and attached to an air-pump, the ordinary spark-gap of the coil being, say, 2 or 3 in. wide, we find that, for some time after working the pump, the electric discharge prefers the inch or two of ordinary air to a long journey through the partially rarified air in the tube, but that at a certain stage of exhaustion, one which any rough air-pump ought to reach, this preference ceases. A flickering light appears in the tube, readily visible in the dark, which very soon takes on the appearance of red streamers like the Aurora Borealis, and then the sparks outside in the common air cease, showing that the rarified air is now the better conductor and the preferable alternative path. Let the exhaustion proceed further, and the axis of the tube becomes illumined with the glow, which is now much brighter, showing a band or thread of current, while the original spark-gap may be shortened down gradually to one-eighth of an inch, or even less, without any spark taking place across it, showing that the rarified air is now a very good conductor. When the best conducting stage is reached, the tube is filled with a glow, called the positive column; and both ends of the tube are apt to look alike. If we exhaust still further—and to exhaust even as far as this something better than an ordinary air-pump is necessary, an oil or mercury pump being the most suitable—the column of light is seen to fill the whole tube, to gradually lose its bright red or crimson tint, and to break up into a number of very narrow discs like pennies seen edgeways. At the same time, the spark-gap must be widened to something more like a quarter or half an inch to prevent the discharge from taking that path, and a dark space near the cathode now begins to be visible, the cathode itself being covered all over with a glow, while the anode is usually only illuminated at a point or two. The striæ into which the positive column has been broken up thicken and separate as exhaustion proceeds. The dark space near the cathode also enlarges, driving, as it were, the positive column before it into the anode, and looking as if it would presently fill the tube; but before it can do this, it is noticed that the glow on the cathode itself is coming off as a kind of shell, leaving another dark space, a narrower and much darker space, inside it. The first dark space has been called Faraday's dark space; the second is generally known by the name of Crookes's. This second dark space now increases in thickness, pushing the glow before it as the vacuum gets better and better; but the terminals of the spark-gap must now be pulled still further apart, else the discharge will prefer to take a reasonably long path through the air. Exhausting further still, the glow all disappears and the second dark space fills the whole of the tube; and now is noticed a new phenomenon, the sides of the glass have begun to glow with a phosphorescent light, the colour of the light depending on the kind of glass used, but generally in practice with a greenish light; a result evidently of being the boundary of the dark space. If exhaustion proceeds further, the resistance of the tube becomes very high, and the spark may prefer to burst through an equal and ultimately even a greater length of ordinary air. This is the condition of the tube so much investigated by Crookes, by Lenard and Röntgen, and by many other observers. It is the phenomena occurring in this dark space which have proved of the most intense interest.

Cathode Rays.

So far we have supposed that the cathode is a brass knob or other convenient terminal introduced into the tube; but if we now proceed to use other shapes, as Crookes did, using a flat disc or a curved saucer-shaped piece of metal, and if we then introduce into the dark space various substances, we shall find that the dark space is full of properties which are most clearly expressed by saying that it is a region of cathode rays—that is to say, of rays or something as it were shot off from the cathode. There is evidently something being thus shot off, which, however, is invisible until it strikes an obstacle, something which seems to fly in straight lines and to produce a perceptible effect only when it is stopped. Such a something might be a bullet from a gun, which is quite invisible when looked at sideways, but may produce a flash of flame when it strikes a target, or may do other damage. So it is with these cathode rays; the region of their flight is the dark space; the boundaries of that space where the projectiles strike are illuminated. A substance with phosphorescent power, such as many minerals, or even glass, phosphoresces brightly, and the path of the rays can be traced by smearing a sheet of mica with some phosphorescent powder and placing it edgeways along their path. In this way it can be shown that they travel definitely in straight lines, not colliding against each other, but each shot as it were like bullets from an immense number of parallel guns. Where they strike the sides of the glass they make it phosphoresce; where they strike residual air in the tube, as they do if the exhaustion is not high enough, they make it phosphoresce also, and give, in fact, the ordinary glow surrounding the dark space.

These rays possess a considerable amount of energy, as can be shown by concentrating them by means of a curved saucer-shaped cathode and bringing them, as it were, to a focus. A piece of platinum put at that focus will (if the exhaustion is not too high) show evident signs of being red-hot—that is to say, will emit light. If the exhaustion is higher, less heat is produced, though a phosphorescent light is emitted from suitable substances like alumina and most earths; but if the exhaustion is pressed further still, the bombarded target emits no visible light but that higher kind of radiation known as Röntgen or X rays. It may be doubted, however, whether the target itself emits these rays, whether its function is not rather to stop the projectiles as suddenly as possible by the massiveness of its atoms. Thus the best target would be a substance with the heaviest atoms. The X rays are probably emitted by the suddenly stopped projectiles in a manner which has been investigated by Sir G. Stokes and Prof. J. J. Thomson, and which is intelligible to anyone who has studied the properties of moving electric charges moving at the speed of light, a matter on which Mr. Heaviside has written with extreme clearness in his volume called "Electro-magnetic Theory."

Cathode rays have a remarkable penetrating power; for Hertz found that a thin metal diaphragm, especially if it were of aluminium, was powerless to stop their passage completely, as could be demonstrated by the phosphorescence and other effects appearing in the further half of the tube beyond the diaphragm.

The position of the anode in such experiments is of small consequence. There must be one somewhere, and the easiest plan is to make it a cylinder through which the cathode ray bombardment goes. The bombarding particles fly in straight lines and decline to turn a corner, taking no apparent notice of the position of the anode, and exhausting themselves by bombarding the side of the glass opposed to them, if the tube is bent into a V shape, for instance.

Lenard extended Hertz's discovery in a remarkable way by skilfully constructing a tube with its outer wall of very thin aluminium, so arranged as to be able to stand the atmospheric pressure outside. He then directed the cathode ray bombardment on to this window or aluminium film, and showed that the rays can penetrate it and actually come outside into the ordinary atmosphere, where they are called Lenard rays, in honour of this indefatigable investigator, a friend and disciple of Hertz.

These Lenard rays make the air phosphoresce and produce the other effects which cathode rays can produce, but they are stopped within a moderate range by the immense obstruction they meet with from a substance of the density of ordinary air. Substances seem to stop them simply in proportion to the quantity of matter which they encounter, without regard to its nature. A thick layer of air would be about as opaque as a layer of water $\frac{1}{100}$ as thick; and even if the body put in their way is a solid, provided it is thin enough and not too massive, it will be penetrated by the rays, and phosphorescent effects will be produced on the other side of it. The rays can also affect photographic plates, and, indeed, do nearly all the things, though on a smaller scale and with much less penetrating power, that the later discovered Röntgen rays can do.

The Lenard rays are clearly cathode rays emerged from the tube, and it was the custom, at the date of their discovery, to think of them as flying charged particles of matter; though the extraordinary distance they could travel through common air, a distance comparable to an inch, was a manifest difficulty to such a hypothesis, seeing that things as big as atoms of matter cannot travel so much as $\frac{1}{1000}$th of an inch in ordinary air without many collisions.

Lenard accordingly adhered to the view that they were not material but ethereal; and although in the sense he probably intended, this is not a tenable view, for they are not ethereal waves or anything of the nature of radiation, yet, as we shall see, neither are they ordinary material particles, any more than the cathode rays are. But that is just what we are now considering, and we will return to them as observed by Crookes in 1879.

Nature of the Cathode Rays.

We have seen that the impact of the cathode rays, speaking in language appropriate to the assumption that they are charged particles, will result partly in heat, or vibration of the impacted particles; partly in light or phosphorescence, due to the quiver of electrically charged atoms, or rather the electrical charges on atoms, as in the ordinary process of radiation; and partly in X rays; all of which effects are readily seen at different stages of vacuum in a Crookes' tube. The *momentum* of the flying particles shot off from the cathode can also be exhibited by putting into their path some form of vane or little windmill, which will then be driven mechanically, as the vanes of a radiometer are driven by the recoil of the molecules of the residual air from the warmer surface, a stress being thus set up between the vanes and their glass enclosure. In the electric vacuum tube experiment, the stress seems to be between the cathode or gun and the vanes or target, and the propelling force would appear to be the force of electrical propulsion, the particles travelling down the grade of potential just as they travel in ordinary electrolysis; but, whereas in ordinary electrolysis they meet with constant encounters, and therefore progress very slowly, in the high vacuum they can fly for several inches in a free path without encountering anything, and therefore without causing any disturbance, giving rise to no appearance but that of the dark space. Phenomena occur only where they strike.

This was the view taken by the whole world, of the nature of cathode rays, after Crookes's demonstration; it was supposed that they were flying atoms, and that they were flying with ordinary molecular speed, but with a long free path—much longer than would have been expected from ordinary gaseous theory. The extraordinary length of free path was somewhat difficult to reconcile with the doctrine that they were flying atoms obedient to the ordinary laws of gases; except that, being subject to electrical propulsion all in the same direction, their course was more regular, and their encounters therefore fewer, than if they had been moving at

random. This same feature of regularity it is that confers momentum upon them; their motion does not constitute heat, and is not to be considered as temperature; they are moving like a wind, rather than with the irregular unorganised motion appropriate, and solely appropriate, to the terms "heat" and "temperature," and to the ordinary kinetic theory of gases. Crookes indeed hazarded the surmise, by one of those flashes of intuition which are sometimes vouchsafed to a discoverer but are often jeered at by orthodox science at the time, that he had obtained matter in a "fourth state," and also that he had got in his tube something equivalent to what was contemplated in the "corpuscular" theory of light. There is something to be said for even this last mode of statement, when the particles are moving quickly enough; but how true the first was—that the matter in the dark space was in a fourth state, neither solid nor liquid nor gaseous—how true that was we shall presently see.

Meanwhile let us summarise the evidence for the view that the cathode rays are at any rate charged particles of some kind in extremely rapid motion. That they are in motion must be granted from the facts of their bombardment—driving mills, heating platinum, and the like; and in order to show that they are charged, the most direct plan is to catch them in a hollow vessel connected with an electroscope, as Perrin did; but another plan is to show that they have the properties of an electric current. If they are charged while in motion, they constitute a current on Maxwell's theory, and therefore should be able either to deflect a magnet, or to be deflected by it; and here comes one of the most simple and important experiments in physics at the present time. A definite form of old experiments by Golstein and many other vacuum tube observers was arranged by Crookes in 1879, when he made the track of the rays visibly luminous, by passing a selection of them through a slit, and letting them graze along the surface of a film of mica covered with phosphorescent powder, and when he then brought near them a common horseshoe magnet. When this is done the track of the rays is at once seen to be curved, showing that it is not a beam of light we are looking at, but a torrent of charged particles behaving like an electric current, and deflected by a magnet. It is really the very same phenomenon as can be observed with difficulty when a current flows through metals, which was discovered by E. H. Hall, and is known as the Hall effect.

The fact that the particles are thrown off the cathode, being evidently vigorously repelled by it, is sufficient to suggest that they must be negatively charged; the direction of the curvature caused by a magnetic field enables us to verify at once that the flying particles are negatively charged, and no comparable rush of positive particles in the opposite direction, or in any direction, has been observed. In that respect evidently the magnetic curvature of cathode rays in gases differs from the magnetic curvature of a current in metals, viz., that whereas in metals it is sometimes the negative and sometimes the positive current which is acted upon, according to the nature of the metal, and the effect is always small, in gases it is the negative alone that appears to be acted upon, and the action is always large. It seems, therefore, that for some reason or other the negatively charged bodies in a vacuum tube are much more mobile than the positive, and that the mobility of the negatively charged bodies is extreme. One striking method by which their mobility was displayed consisted in the observation by Prof. Schuster that all parts of gas in a closed vessel became conducting when an electric discharge had taken place in one corner of it, so that even though the vessel consisted of different compartments, one compartment was made feebly conducting by a discharge in the other, provided that the two had any kind of gaseous communication, a fact which looked as if some extremely mobile particles, probably the negatively charged particles of cathode rays, could wander about to a considerable distance in a very short time and take their share in the conveyance of an electric current. The conductivity of gases appeared to be, indeed, entirely due to these loose or dissociated or detached charged particles, and where they were absent the gas did not conduct at all; it could be broken down, being a weak dielectric, by a sufficiently strong force, but it would not leak; whereas, when these loose charged particles were about, it leaked readily, becoming, to all intents and purposes, an electrolyte amenable to the feeblest electric influence. And the act of breaking down the air by an electric discharge was found to render the surrounding air for a time thus electrolytic. Its electrolytic quality, however, did not last long. The mobility of the particles, which enabled them to travel to a considerable distance, also enabled them to get rid of themselves by clinging to the sides of the vessel, or perhaps by re-uniting to some opposite but comparatively immobile positive charges, which, after some time, in their rapid journeys, they must casually encounter. Mr. Townsend,* however, found that the conducting power lasted unexpectedly long if no dust was present, the dust particles evidently acting as intermedial receivers and storers of charge, promoting interchanges which otherwise might be delayed from accidental non-collision. And the time that thus elapsed before the whole of the conductivity disappeared from dust-free air suggested that the moving particles must be very small, so that collisions were comparatively infrequent.

The mobility or diffusiveness of a gas depends on its mean free path, and that depends on its atomic size: the smaller it is, the more readily can it escape collision. Hence it is that collisions are so rare in astronomy; the bodies are small compared with the spaces between them. The behaviour of charged particles seemed to indicate that they must, in some cases, be something smaller than atoms. It seemed hardly likely that material atoms could behave in the way they did, so it was recollected that it had occurred to some philosophers, among them Dr. Johnstone Stoney, that electric charges really existed on an atom in concentrated form, acting as satellites to it; so on that view it was just possible that these flying particles might be not charged atoms at all, but charges without the atoms, the concentrated charges detached, knocked off, as it were, in the violence of the discharge and afterwards going about free; travelling at an immense pace because they would still be liable to the full electric force that they had experienced before, and yet would have shaken off the encumbrance of the material atom with which they had been associated. It is true that no such disembodied charges or electric ghosts had ever been observed. All the experiments that had been made in electrostatics had been made on charged matter, the surface or boundary of the matter acting as the locality for an electric charge. The facts of electrolysis had suggested or proved that the atoms themselves could carry charges, and hence that if a liquid were electrified, what was really happening was that a number of the atoms on its surface turned their similarly charged poles outwards; and the same might, for all we knew, be true for metals also, and thus every charge seemed associated with matter.

Yet at the same time the occurrences at an electrode, where an ion gave up its charge and escaped without it, indicated the *possibility* that perhaps the electric charge could exist alone, at any rate that it could be handed from one atom to another, and thus might conceivably exist alone for an instant. During this momentary isolation some might, in the freedom of a rarified gas discharge, possibly escape, and wander about free.

To such hypothetical isolated charges, the unit charge or charge of a monad atom, the name "*electron*" has been given, and when I speak of an "electron" I mean to signify the at present purely hypothetical isolated electric charge. Whereas by the term "ion" I always signify the atom and its charge together.

Now if the flying particles which constitute the cathode rays were electrons rather than ions, if they were detached charges, leaving the atoms behind them (probably leaving the atoms from which they were detached positively charged), their extreme mobility and diffusiveness and high speed would be perfectly natural, and although they would not be matter in the ordinary sense, yet no difficulty need be felt at their possessing some of the properties of matter, at any rate such properties as appertain to matter by reason of its having inertia, because, as we have seen, an electric charge itself does possess a certain kind of imitation inertia. Hence these electrons in movement would possess momentum, and might therefore propel windmills; they would possess kinetic energy, and therefore might heat a piece of platinum, and if suddenly stopped by a massive target when travelling at a high speed they might readily give rise to phosphorescent appearances and even to the sudden pulse of radiation known as X rays. But the existence of this last property ought to be capable of clear deduction on electrical principles if the matter is further gone into.

(To be continued.)

* Mr. Townsend, of Trinity College, Dublin, then working in the Cavendish Laboratory, Cambridge, now Wayniete Professor of Physics in the University of Oxford.

METROPOLITAN ELECTRIC SUPPLY CO.'S ARBITRATION.

(*Concluded from page* 42.)

AT the sitting on December 20th, Mr. Cripps, K.C., addressed the Umpire on behalf of the company, and said he should not attempt to follow his learned friend into the curious fallacies which he called theories of hypothetical analysis. The real thing here was the value of an undertaking compulsorily purchased under the Lands Clauses Act. That the sale was compulsory there could be no doubt, and the words "to estimate the value of an undertaking under the Lands Clauses Act" was no longer really subject matter of controversy so far as the principle was concerned. In this case the concession was for a limited time. When they had once arrived at the proper table to apply there was no difference in principle whether what they were purchasing was in perpetuity or for a limited number of years. There might possibly be an element of novelty in the fact that at the end of the period of concession the plant had to be taken over at its then value. He was not now actually referring to the terms of the Act, and the concessionnaires were no longer entitled to the benefit of the business under the head of goodwill. There again, unfortunately, they had been anticipated under the Tramways Act. The matter had gone to the House of Lords, and the principle to be applied had been determined. Then there was the question of severance, and Mr. Moulton admitted the principle, although there was a great variety of figures. He contended that the figures of the company were accurate, and Mr. Moulton had suggested that there were two matters which, at any rate, ought to influence them more or less in dealing with the figures to which the company said they were entitled in this arbitration. One was what had been called the undue preference point—that was the question of charges in Marylebone as compared with the charges in mid-London. The other was the question of the self-contained system. There was a third point which he would ask to be allowed to deal with once for all—viz., how far there was a probability of competition within the Marylebone area, and how far such a probability would affect the true value of their concession to the Metropolitan Electric Co. With regard to the undue preference point, that was partly a question of fact and partly a question of law.

With regard to the legal point, it would have been perfectly open to the Marylebone Vestry to have commenced proceedings against the company, and to have enforced equality of charges in the two areas. On the question of fact, he thought they had absolutely established their position. In Marylebone and in mid-London they had two differing conditions affecting a large amount of the supply in this sense, that substantially the larger portion of the supply for Marylebone was for residential purposes, and in mid-London it was for business purposes. Mr. Conacher's evidence showed that such differences as existed were due to different conditions—the residential district, the business district, the business carried on under different conditions as regards the load factor—and that the only outstanding cases were absolutely infinitesimal, and could not affect a great question like that at all.

The Umpire: Mr. Moulton put forward with no uncertain voice the construction of the clause to give a valuable right to Marylebone to charge prices which should not exceed the prices in mid-London. He said, supposing that had not been observed, still, we ought always to bear in mind that one element in keeping down prices in Marylebone was the liability to have them kept down to mid-London prices; and mid-London was open to influences—the competition of Charing Cross, and so on—to which Marylebone was not.

Mr. Cripps said he did not object to that. He agreed it was a question of sovereigns. What he did say was that, although Mr. Moulton had put it in that way as a possible element affecting prices in the future, that was very distinct from the view he (Mr. Cripps) put forward that Mr. Moulton used it in the sense of risk for the purpose of attrition. He contended that the most Marylebone could have done was to compel the company to raise certain charges in mid-London. Then, with regard to the question of the self-contained system, the agreement with the Vestry was that the company should provide and fit up generating stations at Rathbone Place and at Manchester Square, and maintain a sufficient plant there for a supply of current for not less than 85,000 lights. That that had been done, he thought, would not be seriously contested. Their view was that the words in the agreement enabled them to supply a stand-by inside or outside Marylebone, so long as these two specified stations were constructed, worked and used, or constructed and capable of being used, up to the standard in reference to which there was no dispute between them. With regard to the question of competition, he thought there had been some misunderstanding. Parliament never would give a monopoly in these cases, but substantially so long as a company did its duty, it was not interfered with. There were only two possible competitors, viz., an outside company or the Vestry. An attempt had been made by an outside company, but in view of the dissent of the local authority Parliament would not sanction the competition. Then the local authority brought in a Bill, and it was thrown out, and then the company pointed out the trying position they were in in being harrassed year after year, and they offered to sell to the local authority. Therefore for the Vestry themselves there was only one attitude, which was that of purchase, and that was the position they were in now. The position now was not that of a monopoly, but of a company whose existing income was not likely to be affected by the introduction of a competitive factor. Coming to the question of the tables, Mr. Cripps said they had first got to form their judgment upon what amount of profit or what amount of earnings would be divided, or probably would be divided, amongst the shareholders during the period of the concession. The first question was as to how they were to approach the question of goodwill. There were two matters to be considered. One was the question of what he would call ascertained amounts, and, secondly, they had the question of future estimate, which must in some of its elements lead to difference of opinion. The company's lowest estimate of future expectations was, roughly, £650,000. On Mr. Moulton's table he reckoned it out at £150,000. However, so far from there being any question of difficulty as regards maintaining income, they had an income guaranteed so far as its present level was concerned by a large future increment. Having ascertained what might be called the normal year, the next problem was the future expectations, and he would deal with that when he came to figures. Then with regard to the valuation of the plant, it had been suggested that as regards plant not entirely up to date or no longer of value having regard to the conditions under which the industry may be carried on in the future, the company were not entitled to a valuation of those items. That, he submitted, was quite inconsistent with the principle of the clause. Then, with regard to severance, the company's figure was roughly £240,000 as against £48,750 on the other side, and those figures he would deal with later. He would point out that on the figures put in by the company there had been an extraordinary small amount of real criticism in the case, and he submitted that the main position of the company, and the main figures of the company, stood as they put them. He was satisfied that as regarded the main points their armour had not been pierced, and the suggestions on the other side had not been in the direction of true criticism of their main position. Mr. Cripps then proceeded at considerable length to criticise the tables put in Mr. Fletcher Moulton, and to challenge the deductions which the learned counsel drew therefrom in support of the case of the Borough Council.

Resuming his speech on December 22nd, Mr. Cripps, after further criticising the tables of Mr. Moulton, referred in detail to the tables which had been placed before the tribunal on behalf of the company. He said that the first upon which he had to make some comment was table No. 3, about which he thought there had been a little misapprehension. It sometimes had been said that the gross revenue in the Marylebone area, which they could ascertain, had been spoken of as though it were £100,833. Now, of course, that was not the gross revenue—it was £100,833 plus £3,104—or in other words, £103,937.

The Umpire: That is gross in the fullest sense before any allowance for bad debts.

Mr. Cripps: Yes, but it is of importance, and I want you to bear it in mind, because in some of the calculations as to the amount sold and the price per unit, particularly in their calculations, the gross income has been taken excluding the meter element, and that is the cause of some of the apparent differences, where we ought to have been at one, between their tables and ours. The first matter we have got to get in 1901 undoubtedly was the gross income of the company. We must start from that point always, and here, apart from any question of estimate or anything else, we have so far a solid foundation, because we can separate Marylebone from the rest of our undertaking. Our books have been looked into, and we are agreed really that the gross income is the figure I gave of £103,937. Continuing, Mr. Cripps said that that table in itself had nothing to do with future expectations, but it had been suggested that it showed what he might call a somewhat conflicting result, and particularly it was said that as regarded the increases in the years 1896 and 1898, it looked on the table as though there had been a certain reaction. But the answer to that was that those were both years in which there was a large reduction in price, or a considerable reduction, and that any apparent absence of the normal increase as regarded gross revenue was attributable to that reason, the result being shown that in 1896 and 1898 the increase in gross income in the year was less than what he might call the average of years on either one side or the other. There was one other note to that table which was of importance, and that was as regarded the first four months in 1902. They might recollect that as the case went on they gave, or offered to give, the actual results from quarter to quarter in 1902, and it was only necessary for him to say that so far as 1902 was concerned, which was the first element in the estimate, as appeared from actual facts, they more than covered the estimate which they made, of course, before the 1902 business had been embarked upon—before it had got beyond the first four months.

Mr. Cane: I think the evidence only goes to the first three.

Mr. Cripps: No; but it is not a matter of very serious importance between us, because our divergences of estimate are really in subsequent years rather than in earlier years; but it is a corroboration which we are glad to point to, and of which my learned friend will realise the value when we are searching for truth—it is an estimate, and he will be glad to recognise that so far our estimate has been corroborated by the fact. As to the next table, dealing with what was called the classification of houses, that showed a number of consumers at the end of each year, and the proportion of estimated possible consumers at December 31st, 1901. The percentage which they got up to the end of 1901 was 22·95. That so far was only the past, and the importance of the bearing it had was as regarded the probable future field in the Marylebone area. As far as the past was concerned there was no question—it was the bearing in the future, whether they were likely to have the field they anticipated, or to be in the narrow limits suggested by Mr. Moulton.

The Umpire: You assume the total possible consumers to be 18,273.

Mr. Cripps: Yes, all through the time, and we do not take into account the increase in the proportion of consumers to houses which will take place as houses already connected become more fully supplied. You will recollect that was a matter on which we relied a good deal. With reference to the table showing the number of units supplied to consumers connected to December 31st, 1899, whose accounts for the year 1901 amounted to not less than £100, and the increase in that year over the first complete year of supply, the meaning of that table was that people who had already taken the supply which was outside the preceding table, where they were dealing with questions of numbers, were in themselves some of the best customers in the future, from their tendency to increase the amount which they were taking. Undoubtedly, when they came to the question of field, it was exceedingly important to note that it was not only a question as regarded houses installed, but also a question of increase of demand in houses where the electric light was already installed. One of the most startling factors regarding the electric light, at all events in the Marylebone district, was the tendency for the market to grow where people had once had the advantage of some electric light installation. It was much in accordance with what they had heard, that at any rate in the better class of houses, the requirement now was that if they were letting it or seeking for a new tenant, there must be provided not only installation, but installation all over the house. Regarding their table as to the estimate for the future, he was most anxious to show that it was moderate and not exaggerated. They had put it under two heads, and one of them was the number of units sold for lighting purposes, and roughly in order to emphasise the difference between them, their estimate of what Mr. Moulton had called saturation point, was double that of the Council. As regarded motor-power, there was all the difference between them, not so much on the question whether there was likely to be a demand, but on the doctrine of hypothetical analysis that that was to be the only company in the United Kingdom which would not be able to supply motor power. He wanted to say generally as regarded motor-power, that if they were to give credit to witnesses, who after all were the great pioneers of questions of this kind—Mr. Swinburne, Mr. Ferranti, Col. Crompton, Mr. Hammond and Sir W. Preece—it would appear that their estimate as regarded motor-power was absurdly under the mark. They had gone to the extent of saying that in their view the consumption for motor power in 1931, as a minimum, would be as large as

the consumption for lighting purposes, and they had said that, even if it were so, it would make very little difference as regarded capital involved, because the result of supplying for motor purposes as well as lighting purposes was to give them so much better a load factor that it was almost all advantage after a certain point. They put a great deal of weight on the motor-power question, and he thought one of the enormous developments, probably, of electric usage in the future would be in connection with the motor-power carriages which were almost becoming common. Without the tribunal was convinced that the Metropolitan Electric Co. in Marylebone was so unhappily constituted that it was impossible to undertake a business of that kind because they could only undertake it at a loss, he did not think that was a very formidable opinion; apart from that, was not their 7,950,000 units a very reasonable estimate? Turning to the question of working expenses, the learned counsel said that, according to the true view, in order to get what he might call the normal year, the working expenses for 1901, when properly adjusted, were 47·74.—Adjourned.

At the thirty-third, and concluding, sitting of the Arbitration, Mr. Cripps, K.C., continued his address, and dealt with various tables on the question of capital. He said that the effect of his table was that they started with £131 of capital per 1,000 units sold, and it was not till 1909 that they got down to £100, and not till 1931 that they got down to £75 per 1,000 units sold. That was the total capital. Therefore when he came to the question of load factor, which was the important point, the determining factor on this question, they must recollect in reference to Mr. Moulton's criticism, who talked about £100 for light and £60 for power, that even upon the company's estimate it was not till 1931 that they got down to the £75 per 1,000 units sold for the two combined. That was almost entirely a question in their view, and all electricians agreed, of load factor, and they could not dissociate it from the business expected, and although, no doubt, as regarded lighting, the tendency was towards a better load factor, because of lighting basements in the daytime, even in a room of the sort they were in there was a tendency to an improved load factor in the lighting alone. It was part of their case—an immense accession of economy, and therefore a business which was in itself a paying business as regards motor power, because they got an improved load factor. It was no use going into Mr. Moulton's argument as to what it would be if there was not an improved load factor, or trying to dissociate it from load factor. Mr. Cripps proceeded to deal with the evidence of Mr. Hammond, Mr. Ferranti, Colonel Crompton, Mr. Swinburne and Sir William Preece on the question of the load factor, and said he thought their evidence showed that as regards costs in the future, estimating capital cost to produce a given result as regards revenue, load factor was the important element to see if sufficient or not had been allowed, and taking that test, these gentlemen whose experience in these matters was above all question, said that on Mr. Conacher's basis the amount had been over-estimated, and in the future market it would cover the larger estimates put in by Colonel Crompton and Mr. Ferranti. He thought also that Mr. Wright came into line with all the other engineers on the load factor point. Then there was the question of the additional capital required as affecting future income; of course that included a question of depreciation, and the amount to be allowed for depreciation and matters of that kind. He did not think there was very much difference between them.

The Umpire: They take 4½ plus 1½, and you take 3½ plus 1.

Mr. Cripps said that was the 4½ taking out the terminal drop doctrine, and therefore he did not think there was much difference between them. Now he wanted to see how far they were apart first on the capitalisation of future expectations. The figure was £644,275, while Mr. Moulton roundly put it at £150,000, so the difference between them was easily seen. That was the most important thing in this case, because when they came to the question of capitalising the maintainable profit it would show the difference between them was £150,000. First of all, of course, there was that difference in field between them, because that underlies the whole question of future expectation, and there was a two-fold difference beween them. One, he thought, was more difficult than the other. One was whether their expectation as regarded the increase in the lighting field was right, or whether that of the company was right, because the expectation of the Borough Council of increase as regards the lighting field was almost exactly half of that of the company. There was no great scientific question involved, nor was there any principle of compensation law involved. The arbitrator had to make up his mind and say which of the estimates was the probable one, having regard to all the evidence.

The Umpire: You want more than expectation; what is the increase of which there is such a reasonable certainty that you are entitled to be compensated on the footing that you have lost it?

Mr. Cripps said that was so. They had to consider the reasonable probability of what the company had lost. The Council said it was an increment as regards lighting which would have gone to 12,500,000, while the company said in was an increment as regards lighting which would have gone up to 24,800,000. In approaching that position, it appeared to him there were two factors. First of all they had to look carefully into the local conditions; and, secondly, consider on a wider basis what was the probable future of the growing demands as regarded electric lighting. Having dealt with the evidence of the witnesses on this point, Mr. Cripps said that as regarded power, he claimed that his figures were more than covered as regarded future expectations. If the Court were going to adopt the view that the Metropolitan Electric Supply Co. was the one company in England which had to delete motor power from its business, of course it had to go; but if that view were not adopted, it came to be a question of quantum only, and there was a consensus of opinion that Mr. Conacher, in plodding along on the respectable and sound line did not give sufficient range to his imagination as regarded the future he put in for motor power. The next proposition was that they had to translate their field into money, and there were two questions there. There was the question of the capital involved, and there was the question of the way they ought to deal with the capital as regarded depreciation, and interest, and matters of that kind, in order to see what deduction they were to take from the gross earnings year by year in order to get at the net revenue. With regard to capital in the future, that depended substantially upon the load factor point, which, again, could not be dissociated whether they were going to introduce the motor business or not, because that materially and immediately affected the question of the power factor. It appeared to him that the only point on which they differed was on load factor—in other words, what they got out of the kilowatt. The only difference he could see between them with regard to future capital was as to which was right as regarded the load factor point in the future, which was complicated by this, that if they excluded entirely the motor power view, that would tend to make the load factor worse than it would be with that element included. Then when they applied their kilowatt to their future market to see what generating power they wanted, it would be more or less according as their load factor was better or worse. Then it came to this—was he extravagant, having regard to the evidence, in taking such a poor load factor as 12 for lighting and a not very rosy load factor such as 20 for motive power? Having dealt with the various other tables put in, Mr. Cripps said he had admitted pretty frankly whenever so far as he could see his armour had been pierced in any way, with the result that he had been able to give the comparable figures practically under every head, and if they were to add to the figures up to the point of the element of ascertained profit capitalised, it gave them a figure of £1,741,481. That was putting it at the lowest figure. What would be the addition for whatithey called the incidental expenses and things of that kind? That would make £1,800,000, and to that they had to add the severance claim, which, according to the figures he had now given, was £314,437, making a total of £2,114,437, as against the original figure of £2,737,422. That was the difference between the figures which he put in on what he called the comparable basis, and the figures as put in in the first instance on behalf of the company, and upon that basis if they came back for a moment to principle—and, of course, only principle would be applied in this case, subject to any question of difference as regarded the application to figures of the principle—was there any real difference between them as to the way of approaching this problem? He did not think that Mr. Moulton really relied upon his own tables except for the purpose of criticism. They must first of all find the normal figure and apply to that the proper multiplier. Now he said that if as was pointed out in Messrs. Michael & Wills's book, there ever was a case where the 3½ table was justified, it was in that case. It was not an income as to which there was any risk as regarded the future. It was an income which was supported even on the Council's own tables to about twice its present amount. He did ask most earnestly from the point of view of other settlements as between Corporation purchasers and the shareholders of the company in a case of this kind, that here the 3½ per cent. table was applicable, and he said it was a case in which it ought to be applied. Now, as regarded the future. Everyone must admit that there was, in this case, a large area of difference of opinion as regarded field and as regarded cost in the future, because of the capital item. He said, so far as an estimate in the future could be relied upon, there must be the conjectural element in it. So far as it could be relied upon, the company had substantiated theirs, and he certainly claimed it as important that the answer to it was: "As regards light, we go half-way, and as regards motor-power, all that we can say is, that, owing to questions of cost, you can never supply it at all."

Mr. Cane: 3,000,000 units is our figure for power, given by Mr. Wright.

Mr. Cripps said he would take it that that would be, in some senses, half the company's table as regarded that. He understood Mr. Moulton's argument was that power could not be supplied at all, but he would take what Mr. Cane said on that. Having got that, they came together again, because, though in the first instance he asked for 5 per cent. throughout in their tables, he had assented, because he wanted to see what the true basis was, that it was not unfair to take 5, 7½ and 10; but in doing that, what they must recollect was, that they had brought in the element of uncertainty which, no doubt, was an incident in every estimate; and, therefore, the estimate itself, if they thought it was sound, should be accepted; but they had got that element of uncertainty not in the estimate, but in the table on which they capitalised. Well, he thought the view of the company was correct. They were dealing with a property which, according to the supposition, was to be kept up and to be renewed and repaired as the case might be, and he should have thought in a matter of that kind certainly they ought to have the 3½ per cent. table as against the 5 per cent. table. When they came to the question of severance, there was again a wide difference between them, but he did not think much principle was involved. Of course, if the tribunal thought the company had considered their capital idea too long, or if they thought, as regarded cost of production, the company asked for too large an amount, owing to the loss of their Marylebone business, that was a question of fact on which the tribunal would adjust. But after all, their figures in the aggregate came to £2,114,437, and he knew that he would be told he was descending to prejudice when he told them that was a smaller figure than in the market estimates before this question arose. He did not know whether the persons who invested were misled, and he was not going into a matter of that kind.

The Umpire: He may have put his faith upon Whitehall, and not upon Marylebone—the whole undertaking.

Mr. Cripps said that was quite true. The investor may have thought that whereas the company said Marylebone was the plum of the undertaking, it was, in fact, a white elephant to the undertaking. They knew that people did not go into those somewhat minute calculations. He wanted, on behalf of the company, in the very strongest sense, to combat such suggestions when the tables were put in—the Stock Exchange table and the table as regarded Birmingham and Dover. He wanted to combat what was merely the prejudice of the case put in by gentlemen on the other side—the suggestion that they were asking for anything like an exaggerated amount, even if they took the market estimate of the position. So far as they had been attacked critically, they only wanted a just solution of those questions between themselves and the Corporation. In concluding his address, Mr. Cripps thanked the tribunal for the kind attention they had given throughout the long case.

This concluded the public proceedings, and the award will be made in the usual way.

ELECTRICITY ON BOARD SHIPS.

(*Concluded from page* 36.)

CONTINUING, Mr. F. O. Blackwood said that the electric power must be divided into two separate plants, each large enough to supply the maximum load of the entire ship, for example, into two units of 300 KW. each. The four steam turbines and generators would therefore each have a rated capacity of 400 H.P., with an overload capacity of 600 H.P. In port or when cruising at slow speed, one 300-KW. unit would be all that would ordinarily be required.

The use of four units instead of eight will much simplify the electric installation. The proposed four 300-KW. units would certainly not weigh more than one-half as much or take more than one-third the space of eight 100-KW. engines and generators which are to be installed.

The three branches of a three-phase alternating circuit can either all be joined only at one end, known as the Y-connection, or at both ends, known as the delta connection. In the Y-connection the potential between the terminals is 73 per cent. more than between the common or neutral point and one of the terminals.

Assuming that the new standard generator potential of the Navy (125 volts) will be used for lighting, and that the lamps will be connected between the neutral and one line, the potential between the three-phase lines will be 220 volts. This gives a single-phase low-potential wiring system without introducing any complications and a higher pressure power system. By grounding the neutral, the strain on the insulation might be limited to 125 volts, but this is hardly necessary, as 220 volts is not a high enough potential to cause any trouble. If it were grounded, single-wire lighting circuits might be employed with the ship as a ground return. Such a system could not be safely used with continuous current on shipboard, on account of the danger of electrolytic action corroding the ironwork, or the currents setting up magnetic fields that might affect the compasses. The inductive drop in a single-wire system would probably make a two-wire preferable, however.

The total number of incandescent lamps on the *Connecticut* and *Louisiana* will be about 1,200, requiring 60 KW. with every lamp burning. Probably 30 KW. is nearer the usual load, or, say, 5 per cent. of the two generators in use at one time. One leg of a 300-KW. generator will carry this without difficulty, and the potential of the generator can be automatically regulated to give constant potential at the lamps. If desired, a feeder regulator to boost or lower the lamp potential can be inserted in the lighting circuit, making it possible to control the lamp pressure independently of the speed or voltage of the power system.

The lighting regulation of a large marine power plant of this character, notwithstanding the much greater motor load proposed, can, by means of the automatic devices now perfected, be kept much more constant than in existing continuous-current marine practice and permit the use of three-watt per candle-power lamps instead of the low-efficiency four-watt lamps now generally employed. This would mean a saving of 25 per cent. in the cost of power for lighting.

The six searchlights of the *Connecticut* and *Louisiana* will take 80 amperes each, and 65 volts to give a steady light. When operated from a 125-volt circuit, 60 volts must be used up in resistance. By employing a motor-generator set or rotary converter transforming from alternating current to 60 volts continuous current, the power consumed by the searchlights is cut in two. Alternating current does not give as good results for searchlights as continuous, as there is no crater to the carbon where the light is concentrated, and which can be placed in the focus of the reflector. The result is that the beam of light is diffused and unsatisfactory.

The present system of turret-turning, in which the speed of the motor is regulated by varying the field strength of a continuous-current generator, gives such perfect control over the training of guns that it can hardly be improved upon; but Mr. Blackwood suggests that the same method of control be adopted for elevating and depressing the guns. At present the guns can only be loaded in one position of the turret and elevation of the breech. The ammunition hoist and rammer can readily be arranged so that the guns can be loaded in any position of train or elevation (as in the Vicker's gun mounts in the English Navy), and even while the gun is in motion. A controller similar to that used for searchlights with a single handle for both vertical and horizontal movements would permit a 12-in. gun to be manipulated as easily as a small arm. By keeping the gun constantly aimed at the target, regardless of the motion of the ship, it could be fired the moment the breech was closed, and the rapidity and accuracy of fire greatly increased.

It has been proposed to turn turrets by switching a continuous-current motor on to a number of different potentials supplied by several generators. A system of operation with alternating currents, similar to this multiple-voltage method, can readily be made by having motors with changeable poles and motor-generator sets to furnish current at different frequencies. It could not, however, have the exact control from an almost imperceptible motion to full speed, the minute changes in direction, and the instant response to the will of the gunner, required for accurate marksmanship.

In order to operate the six turrets of the *Connecticut* and *Louisiana* even with continuous current, it will undoubtedly be desirable to have a motor-generator set for each turret so that no additional complication is introduced with the alternating system. With balanced turrets, the power required to move them is small, and a high-speed motor-generator set would be light and occupy little space.

The long line of piping required to operate the steering gear by steam is most objectionable, as it heats up the ship and cuts through the water-tight compartments. It is also inefficient on account of the constant condensation in the pipes, which must be large enough to carry the maximum load, although the average load is very low.

This is another case where continuous-current has decided advantages. The steering engine is constantly starting and stopping, and will take 100 H.P. at times, so that any method of control which requires the making and breaking of heavy current is objectionable. A modification of the variable potential control used for the turrets, in which only a small field current passes into the controller, would be best for electric steering. A motor-generator set would, therefore, be required, with a continuous current motor applied at the rudder.

The large amount of power required to operate the anchor windlass has heretofore been an obstacle to driving it by electric power. With the larger electric plant and units proposed, this objection would no longer exist. A single 300-KW. turbo-alternator is ample to handle the heaviest windlass. For this purpose a changeable-pole motor might be designed which would give a heavy torque at slow speed, or even when entirely "stalled." The slow speed would be used for starting the ship and breaking out the anchor, while the higher speed would be employed for hauling in the chain.

Hoisting with induction motors presents no difficulties. The continuously running hoists would be driven by constant-speed motors. The cable hoists would have variable-speed motors, permitting the hoist to be started gradually and run below synchronous speed. The method of control can be either primary or secondary. Instead of solenoid brakes, which are impracticable with alternating-current, automatic mechanical brakes would have to be used, although small alternating solenoids might be added for retarding the armatures.

The speeds of blowers could be much increased over those now used, especially with alternating motors. Higher efficiencies and much reduced weights of both motors and blowers could be obtained by increasing the revolutions and reducing the diameters. It would be better to keep a constant pressure in the ventilating system and let the amount of air to be supplied be regulated by opening the outlets. In addition, changeable-pole motors might be employed to give, say, three-quarters and full speed, or two-thirds and full speed. It is stated that the variation in speed of continuous-current motors by field control cannot yet be obtained efficiently with alternating motors.

In order to make small reductions in the air pressure delivered with alternating-current motors, either the outlet of the blower must be partially closed, or the speed of the motor reduced by losing a certain amount of power. Both methods are more efficient than might be thought at first. A blower is practically unloaded by closing the outlet, and a small reduction in speed greatly reduces the pressure.

Centrifugal pumps have recently been built in Europe and this country for discharge heads up to 500 ft. by using high speeds and having a number of runners in series. There will soon be no difficulty in obtaining these to replace reciprocating pumps for all purposes on shipboard with practically the same efficiencies and with but one-third the weight. These pumps are particularly well adapted to be run by electric motors. Their high speed gives a small, light, and efficient motor. They avoid entirely all gearing, valves, and reciprocating parts, and, consequently, much of the noise, vibration, and repairs incident to the operation of reciprocating pumps.

They do not require much variation in speed in order to largely change their capacity. They can be used to maintain nearly constant pressure at constant speed with a variable delivery. If the outlet is closed, there is no great increase in pressure, and the pump unloads itself like a blower. If the outlet is partially opened the pressure decreases somewhat and the pump begins to feed. With a

constant head a small variation of speed will make all the difference between the pumps delivering full capacity and doing no work. With such pumps available there need be no reciprocating pumps on shipboard with the exception of those for air.

Where these centrifugal pumps are to be run at widely different pressures or capacities, some of the runners may be cut out entirely or put in multiple with each other. Changeable-pole motors can also be advantageously employed.

In conclusion, Mr. Blackwood expressed the opinion that the steam turbine is the coming method of driving generators. Its rotary motion, light weight, small size and high efficiency at all loads make it particularly suitable for marine use.

Alternators are best adapted to be driven by high-speed turbines, but alternating current has both its merits and demerits. For transmitting power polyphase current is most economical, and the induction motor for constant speed cannot be equalled for simplicity of construction and ability to stand hard usage. It does not, however, permit of as economical or exact speed regulation as a continuous-current motor, although there are possibilities of the development of an alternating commutating motor which will meet these requirements.

As the majority of motors on shipboard run intermittently at variable speed, the selection between continuous and alternating-current should only be made after thorough investigation.

THE SHOCK FATALITIES AT FULHAM.

On Saturday last Mr. J. L. Drew, coroner, and a jury resumed and concluded the inquest touching the fatalities on the 23rd ult., when two men were said to have lost their lives through an electric shock received by them while in the Fulham Public Baths. Mr. G. S. Ram, M.I.E.E., one of H.M. Inspectors of Factories, had been sent down by the Home Office as an expert, and occupied a position on the Coroner's Bench. Though the place where the fatalities occurred came under the jurisdiction of the Board of Trade, that body was not represented.

Dr. Williams, recalled, said he was of opinion that death occurred at the time the fuses were withdrawn. The shock would be at its maximum when that was done.

Other witnesses gave evidence as to having received shocks at the time of the accident.

Mr. H. D. Pearson, architect, of 27, Chancery Lane, said he was employed by the Corporation to carry out the whole of the bath buildings, including the engineering work and the electric light. He employed Mr. Hilton Johnson as consulting electrician, and paid him the usual fees. Mr. Hilton Johnson represented witness during the work, which he examined and passed as in accordance with the specification. There was no alteration that witness knew of. Mr. Pearson detailed the construction of the baths, and said that the electric wires were carried along the tops of the partitions in metal tubes. The partitions were of slate, fixed by metal feet in concrete, and held together by galvanised iron capping. The iron tubes containing the electric wires rested on the capping, which was flanged and joined together. There was a waste pipe of gun-metal in the baths, which came up from the basement through holes in the floor. The floor was composed of concrete and rested on a support of expanded steel. That was a conductor of electricity. There was no direct connection with the galvanised iron work, because the whole of the partitions were of enamelled slate, and it was impossible to make a connection through the partition. The electric fittings were all metal. He had arranged similar baths before, and there had been no shocks in connection with them that he knew of. The tubes containing the wires were of iron, and the wires themselves were insulated by rubber and silk; but he (witness) was not technical enough to explain it.

By Mr. Moyses: The whole specification and the whole of the electric system was prepared for him by his electrical engineer. The baths were lighted by lamps which were supported by saddles over the partitions between the cubicles. The tube system was the safest in a building such as that in question (where there was likely to be rough play) if his specification had been carried out. He believed a leakage had been discovered through one of the lamps, but could not say the cause. It might have been a defect in the work, either in the wiring, the lamp, or the fitting. He believed the tubes were wired length by length.

Mr. Ram: But the Council's requirement was that the conduits should be "earthed," was it not?

Witness: Yes, and if they had been earthed no shock could have arisen from the wires.

Mr. F. H. Medhurst, of Victoria Street, Westminster, said he had carried out the electricity undertaking of the Fulham Corporation at a cost of nearly a quarter of a million pounds, but he had no part in the supply or the fixing of the electric light in the baths. He went there on December 24th at the instance of the Town Clerk, because of this unfortunate occurrence on the 23rd, and made an investigation. The man undoubtedly received a shock by completing a circuit between the metal capping and the earth. He did that by putting his hands on the metal capping, and his body being immersed in warm water, possibly over the disc in connection with the waste pipe, he would naturally have been in the best conceivable position in which to offer a very low resistance to the passage of the electric current; there being an "earth" somewhere else he completed the circuit, and in that way received a fatal shock.

The Coroner: But for that to happen there must have been a leakage?—Undoubtedly. My experiments proved that. I experimented to ascertain the electromotive force, and they proved that the man would get a shock of 165 volts, while the electromotive force at the lamps was 205.

Did your experiments prove that the maximum shock was received at the time when the fuses were withdrawn?—I heard the doctor say so, but I should not care to say so. I know that opinion is held in some quarters, but it is impossible to give very definite information, because, of course, no one has been able to sacrifice himself and tell the story afterwards.

Further examined by the Coroner, Witness said that since the previous sitting, he had made an examination of the premises and found that the defect was in the connection between the wires and the lampholders to which they were attached. He did not mean to say that was so in all the cubicles, but it was not material in a metallic tube system. When he removed all the lampholders and straightened out all the wires, there was no longer any electrical connection with the tubes.

To what do you attribute the defect?—To the fact that the specification was not carried out, and that the tubes containing the wires were not "earthed." It was impossible to say how long these imperfections had existed. The leakage probably had existed since the baths were opened.

Supposing the specifications had been carried out, what would you say about the system?—If the specifications had been carried out, it is totally impossible that any one could have received an inconvenient, much less a fatal shock. If the metal tubes were earthed there could be no possible danger. The fuse controlling the circuit would have melted, and the lights gone out.

By Mr. Moyses: I would correct the omission in the system by connecting a piece of wire between the tubes and the waste pipe or water pipe. The cost of that would be about 1s. The leakage was in the metal lampholder, where the wire was bent about and doubled. It might have been caused by the shaking of the saddles, which were not firmly fixed. It would not necessarily be bad workmanship. Both the alternating current and the direct current systems were equally safe if proper precautions were taken in the wiring of the building. There was nothing to choose between them from the standpoint of public safety. The leak might have been brought about by friction rubbing off the insulation. He did not try all the saddles, but some of them were not very firmly fixed, and were susceptible to shaking.

By Mr. A. J. R. Marriott, solicitor (who represented the firm which carried out the installation—the National Wiring Co.): He came there as an absolutely independent expert. He was in receipt of commission from the Corporation on the actual outlay involved in their electricity works, but that did not include the services he had rendered in this matter, for which the Corporation were to pay him a special fee.

And your evidence is an attempt to shift the blame from the Corporation of Fulham on to the shoulders of the contractors who carried out this work?—No. I think it is a fair thing to say that my evidence has been a plain and unvarnished statement of fact. You cannot shift a thing which never existed.

Further cross-examined, Witness said that with regard to that part of the specification which required that the whole of the work was to be carried out in accordance with the existing rules as framed by the Phœnix Fire Office, those rules had not been complied with.

Mr. Marriott: If I put it that 80 per cent. of these tubes were earthed, could you contradict it?—If it is so, it is a mere fortuitous circumstance. They are not deliberately earthed.

Are you aware that the specification deliberately provided that the tubing should not be continuous?—I should say it did. Inferentially it does not say so in so many words.

Mr. E. A. Mitchell, electrical engineer, and representative of the National Wiring Co., said that the installation in this case was carried out by his firm in accordance with the specification, with the exception of a few deviations in regard to the tubes, and these had the sanction of the consulting engineer. He suggested that iron boxes should be used instead of wooden ones, as then there could be no possible escape of current, but the architect would not permit it. The work was finished in September, 1901, and the final tests by the officials of the Borough Council proved that the installation was satisfactory. Witness was examined in considerable detail with regard to the method of wiring, and agreed with Mr. Medhurst that there had been leakage, but he thought it was due to moisture or the shaking of the lamps. He himself had suggested the adoption of continuous tubing, and if that had been carried out the accident would not have occurred.

Mr. Ram, in answer to the Coroner, said he had examined the premises.

The Coroner: Can you tell us whether this system is a safe one or not?—I think, but for one defect, the system would have been as safe as it possibly could be. The one defect, to my mind, was that the tubing was not earthed sufficiently, from an electrician's point of view. I should think it was not earthed in accordance with the Phœnix Company's regulations.

With regard to the cause of death, do you agree with the evidence?—Yes, I do, and I should like to say that I think the circumstances were exceptional. The conditions were favourable for an occurrence resulting as this did; but as this case has received so much public attention, I hope it will not cause alarm among those who indulge in electric lighting in their houses. Conditions such as these are very unlikely to occur in houses where the wires are cased in wood, which is almost a non-conductor. If, in this case, continuous tubes had been used, well earthed, there would have been no danger. It all depended on earthing or not

earthing. Moreover, the tubes and fittings should be out of the reach of bathers.

The Jury found that the deceased died from syncope caused by an electric shock, owing to the faulty design and construction of the electric lighting installation. They were unable to say on whom the blame rested. They expressed sympathy with the families of the deceased.

Mr. HUDSON stated, on behalf of the Corporation, that Mr. Medhurst had been instructed to make a complete examination of the Baths in the public interest, and to do whatever was necessary to make them absolutely safe in every way.

THE CHATHAM CAR ACCIDENT: BOARD OF TRADE REPORT.

MAJOR J. W. PRINGLE, R.E., Inspector to the Board of Trade, has made his report concerning the recent fatal tramcar accident at Old Brompton (Chatham). Our readers are fully acquainted with the details of the disaster. The Major arrives at the following conclusions:—

"The cause of this lamentable accident was undoubtedly excessive speed on a steep gradient and sharp curve. The company, in their rules and regulations for motor men (p. 10), have fixed the maximum speed down Westcourt Street, and round the curves into Dock Road, at three miles an hour, with the object of impressing upon drivers the absolute necessity of keeping within the limit of four miles an hour fixed by the Board of Trade. From the evidence it appears that the speed of the car 150 yards from the starting point was from 10 to 12 miles an hour, and it is probable it was as high as, if not more than, 15 miles an hour when the derailment took place. As a further check upon the action of drivers down this hill the company appear to have appointed two of their most competent drivers to act as pilot men. Driver Pearce, who was in charge of Car No. 19 when the accident occurred, admits that he was aware of the company's rule forbidding cars to be taken down the hill without a pilot man on board. Nothwithstanding, although he saw Coffey near the bottom of the hill, he started down the hill without him. It is but fair to say that all the evidence proves that Pearce did wait for four or five minutes before he started down the hill. It is unfortunate he did not wait longer, for the accident is unlikely to have happened with a more experienced driver on the car.

"The initial cause of the high speed attained was, I think, the locking of the wheels by the unskilful application of the brake power, the rails being in a very slippery condition, and the load a heavy one.

"The evidence of pilot Coffey on the position of the brakes after the accident is to the effect that the track brake was screwed down hard, the wheel brake was applied very tightly and held on by the pawl and ratchet, and there were three notches of the electric brake on.

"Rule 13 (regulations for the use of brakes) states that the slipper and electric brakes alone are to be used in going down Westcourt Street. Rule 8 states 'in going down a gradient with hand brake, if the wheels are liable to skid, hold the brake by the hand, but do not lock it by the ratchet and pawl.' Rule 9 states 'before putting on electric brake release hand brake, as electric brake will not act if wheels are jambed. In all cases when using the electric brake use plenty of sand.'

"Driver Pearce, judging from the condition of the brakes after the accident, appears to have acted contrary to all these rules. The statement of pilot Coffey, and evidence I heard at the coroner's inquest, prove, in my opinion, that there was no sand found on the rails after the first 20 or 30 yds. of the descent.

"I come to the conclusion, therefore, that driver Pearce is responsible for this accident, in that, under searching conditions of load and rail, he failed to utilise the brake-power at his disposal in an efficient manner. He is also clearly responsible for disobedience of the company's orders in leaving the stopping place at the top of Westcourt Street without a pilot man. Pearce bears an excellent character, and had been employed as a motor man from the beginning of June.

"So far as the pilot man is concerned, I am of opinion that one most essential part of his duties (as described in his evidence) was the cleaning and sanding of the rails on this hill. The most important time of the day for the fulfilment of this duty was in the early morning, before the first car travelled down the hill. Coffey's tour of duty, judging from his statement, commenced at 6.40 a.m., in which case it appears that the tour was not calculated so as to permit of his performing this part of his duty when it was most urgently required, for the accident happened at about the time his duty commenced.

"The speed was so great on the occasion of this accident, that a derailment on the curve in question was, I think, inevitable, whatever the conditions had been. But I wish to point out that instead of the provision of super-elevation of the outer rail to the extent of from 1½ to 2 in., which is necessary for a speed of from 4 to 5 miles an hour, the outer rail is actually at the commencement and termination of the sharp curve, ¼ in. lower than the inner rail. The question of super-elevation, also, having in view the greater tendency of wide double-decked cars to overturn on a narrower gauge, is of larger importance on a gauge of 3 ft. 6 in. than of 4 ft. 8½ in.

"As regards the gradients on this road, I desire to point out to the Board of Trade the inaccuracy of the deposited plans, on which no steeper gradient than 1 in 11 is shown; whereas a portion of the hill, from actual survey, was found to be as steep as 1 in 9·5. Further, I understood, from the representatives of the British Thomson-Houston Co. at the time I made my inspection, that the curve in question had throughout a radius of 60 ft., whilst, in reality, a considerable length of it has a radius of 36 ft.

"I have been informed by the company that there is a probability of their obtaining an easier approach from Old Brompton to Chatham than Westcourt Street, and that if their negotiations for this new route fall through, they will be able to increase the radius of the curve throughout to 60 ft., and provide the necessary super-elevation. One or other of these courses will be necessary, and the board will no doubt await further information from the company. In the meantime the traffic in Westcourt Street has been stopped, and I concur in the advisability of this procedure.

"So far as I am in a position to judge, the company train their drivers on very similar lines to those adopted elsewhere. It is difficult to understand the statement of driver Pearce that the use of the reverse current in cases of emergency as a last resort to check high speed when a serious accident is imminent, was unknown to him. It is true that the company's rules for brakes contain no mention of the use of reverse current, but I cannot believe that any man of ordinary intelligence could operate a tramcar for nearly six months without being aware of the practical utility of reverse current as a possible means of avoiding an accident.

"It is no doubt difficult, and possibly dangerous, to train men practically to meet all emergencies; but something more may perhaps be done in this way than is done at present. I suggest that heavily ballasted cars should be used not only during the period of training, but also at intervals after the permanent appointment of motor men, as a means of testing their knowledge and efficiency—such tests to be conducted under the severest conditions compatible with safety.

"The company's cars provide seating accommodation for 50 passengers. In this case, the car being one of those run for Dockyard workmen, there were from 10 to 15 additional passengers; five or six of these at the time of the accident were standing on the upper deck. Under ordinary circumstances such an additional load is not likely to be the direct cause of an accident; but it is possible to imagine circumstances in which any considerable addition to the ordinary load may unduly diminish the margin of safety.

"The worst position for standing passengers to occupy is the upper deck. Not only do they here run greater risk of injury to themselves in the event of an accident, but the additional weight at that elevation increases any tendency to overturn which a car may have acquired owing to centrifugal force.

"It is clear from the evidence that the company have experienced great difficulty in preventing their cars from being occupied by a larger number of passengers than seating accommodation is provided for. This is at all events the case as regards the car service for dockyard employés, although the company have, I understand, quadrupled the extent of that service rendered obligatory by the Light Railway Order. The result has been that Rule 6, page 13, of the company's regulations, so far as this particular service is concerned, may be said to have practically fallen into disuse, although special inspectors have been appointed to control the traffic as far as possible.

"That portion of Rule 6, however, which forbids outside passengers being allowed to stand on the roof, should at all events be rigidly enforced."

NEW PATENTS, 1902.

Compiled expressly for this Journal by W. P. THOMPSON & Co., Electrical Patent Agents, 323, High Holborn, London, W.C., and at Liverpool, to whom all inquiries should be addressed.

28,263. "Improvements in motors and regulating devices for controlling and economising electrical energy on electrically-propelled vehicles." J. S. RAWORTH. December 23rd.

28,266. "Improvements in and relating to arc lamps." T. L. CARBONE. December 22nd.

28,268. "Improvements in electrical resistance coils." H. P. DAVIS. (Date applied for under Patents Act, 1901, December 26th, 1901, being date of application in United States.) December 22nd. (Complete.)

28,298. "The electro-signalgraph." R. A. LOVELAND. December 23rd.

28,303. "An electric lamp support and flexible cord protector." T. BARTON. December 23rd.

28,304. "Improvements in automatic minimum and reverse current circuit breakers." B. THOMAS and E. THOMAS. December 23rd.

28,309. "Improvements in or connected with electric fans." G. DAVIS. December 23rd.

28,322. "Improvements in telephone exchange working." B. S. COHEN. December 23rd.

28,351. "An electrical fire caldron." H. PEIRSON. December 23rd.

28,353. "Improvements in electrolysing processes and appliances." J. WETTER. (The Elektrizitäts-Aktiengesellschaft vormals Schuckert & Co., Germany.) December 23rd.

28,380. "Improvements in locking devices for electric glow lamps and the like." J. DENYERS and T. MCLEISH. December 23rd.

28,393. "Improvements in meters for indicating the state of charge of an electric battery." A. C. KELLY. December 23rd.

28,396. "Improvements in enclosed arc lamps." T. HAMILTON-ADAMS. December 23rd.

28,403. "Improvements in or relating to electric couplings, connectors and the like." Sir D. L. SALOMONS, Bart. December 23rd.

28,414. "Improvements in the regulation of electric motors." VICKERS, SONS AND MAXIM, LD., and A. D. WILLIAMSON. December 23rd.

28,429. "Improvements in and relating to electric trolley collectors." E. W. WYNNE. December 24th.

28,448. "Improvements in telephones." B. BRANDER. December 24th.

28,485. "Improvements in regulating electric circuits." H. LEITNER and R. N. LUCAS. December 24th.

28,486. "Improvements in electric switches." H. LEITNER and R. N. LUCAS. December 24th.

28,487. "Improvements in means for controlling variable speed dynamos." H. LEITNER and R. N. LUCAS. December 24th.

28,509. "Improvements relating to the transmission without wires of electro-magnetic signals." H. H. LAKE. (J. S. Stone, United States.) December 24th.

28,510. "Improvements in connection with the trolley poles of electric tramcars and the like." C. R. F. HOMMEL and R. J. HOMMEL. December 24th.

28,515. "Improvements in wireless electric telegraph systems." H. H. LAKE. (J. S. Stone, United States.) December 24th.

28,518. "Improvements in electric lampholders." H. HIRST and V. ZINGLER. December 24th.

28,521. "Improvements in electric wireless telegraph systems," H. H. LAKE, (J. S. Stone, United States.) December 24th.

28,523. "Improvements in and relating to electric accumulators." H. J. HADDAN. (Société Francaise d'Accumulateur Tudor, France.) December 24th.

28,539. "Improvements in electro-magnets and armatures actuated for translating electric current into action." A. FAVARGER. December 24th. (Complete.)

28,549. "Improvements relating to wireless electric telegraph systems." H. H. LAKE. (J. S. Stone, United States.) December 24th.

28,550. "Improvements relating to electric wireless telegraph systems." H. H. LAKE. (J. S. Stone, United States.) December 24th.

28,551. "Improvements in conductors or oscillators for use in electrical wireless telegraphy." H. H. LAKE. (J. S. Stone, United States.) December 24th.

28,552. "Improvements relating to conductors or oscillators for use in electrical wireless telegraphy." H. H. LAKE. (J. S. Stone, United States.) December 24th.

28,586. "Improvements in electric switches for stopping and reversing electric motors." G. H. WHITTINGHAM. December 27th. (Complete.)

28,643. "Improvements in trolley heads for overhead electric traction." F. KENNINGTON and D. L. FAWCETT. December 27th.

28,654. "Improvements in apparatus for controlling and directing electric currents in connection with dynamo-electric machines." J. ATKINSON. December 29th.

28,667. "Improvements in and connected with the electric transmission of energy without connecting wires." L. H. WALTER. December 29th.

28,669. "Improvements in telephones and apparatus connected therewith." C. S. F. MELLOR. December 29th.

28,728. "Improvements in fusible safety devices or 'cut-outs' used in connection with electricity systems." G. MACGREGOR. December 30th.

28,731. "Improvements in conduits or carriers for electric cables." W. OATES. December 30th.

28,736. "Improvements in glass bulbs or globes for incandescent electric lamps and the like." P. KENNEDY. December 30th.

28,744. "Improvements in etheric telegraphy." W. JAMESON and THE SCOTTISH WIRELESS ELECTRIC SYNDICATE. December 30th.

28,746. "A new and improved method of laying and insulating underground conductors for the transmission of electrical energy." H. GODDARD. December 30th.

28,761. "Improvements in motor despatch boxes for use in an electric postal service." R. T. PISCICELLI. December 30th. (Complete.)

28,762. "Improvements in or relating to railway electric signal systems." A. J. BOULT. (S. W. Huff, United States.) December 30th. (Complete.)

28,768. Improvements in and relating to insulating supports for electric conductors." J. M. ANDERSEN and A. ANDERSON. December 30th. (Complete.)

28,770. "Improvements in receiving apparatus for wireless telegraph systems." E. DIAKOFF. December 30th.

28,783. "Improvements in storage or secondary batteries." H. H. LAKE. (C. H. Clare, United States.) December 30th. (Complete.)

28,789. "Improvements relating to rheostats or heaters." C. E. FREEMAN. December 30th. (Complete.)

28,792. "Improvements in electric heaters and rheostats." M. C. KRUEGER. December 30th. (Complete.)

28,805. "Improvements in galvanic batteries." THE HALSEY ELECTRIC GENERATOR CO., LTD. (The Halsey Electric Generator Co., United States.) December 30th. (Complete.)

28,806. "Improvements in galvanic batteries." THE HALSEY ELECTRIC GENERATOR CO., LTD. (The Halsey Electric Generator Co., United States.) December 30th. (Complete.)

28,807. "Improvements in galvanic batteries." THE HALSEY ELECTRIC GENERATOR CO., LTD. (The Halsey Electric Generator Co., United States.) December 30th. (Complete.)

28,808. "Improvements in and in connection with galvanic batteries." THE HALSEY ELECTRIC GENERATOR CO., LTD. (The Halsey Electric Generator Co., United States.) December 30th. (Complete.)

28,819. "New or improved method of and apparatus for electro-magnetically transmitting power." W. C. HEAD. December 30th.

28,820. "Improvements in electrodes for primary batteries." T. MANN and C. GOEBEL. December 30th.

28,822. "Improvements in regulating devices for controlling and economising electrical energy on electrically propelled vehicles." J. S. RAWORTH. December 30th.

28,828. "A new or improved method of protecting electric cables from the effects of current surgings." W. DU BOIS DUDDELL and C. P. SPARKS. December 30th.

28,829. "An improved circuit breaker for overhead electric conductors especially for tramways on the trolley system." G. BELLANGE. December 30th.

28,857. "Improvements in electric switches." H. PIEPER. December 31st.

28,858. "Improvements in electric rheostats." H. PIEPER. December 31st.

28,868. "Improvements in trolleys for electrical tramcars, and other electrical vehicles." R. H. RAINS. December 31st.

28,915. "Improvements in switches for electric circuits." H. R. STUART. (Date applied for under Patents Act, 1901, January 5th, 1902, being date of application in United States.) December 31st. (Complete.)

28,932. "Improved safety apparatus for use with overhead electrical tramways." H. F. HILL. December 31st. (Complete.)

28,943. "Improvements in or relating to electrical measuring instruments." R. APPLEYARD. December 31st.

PUBLISHED SPECIFICATIONS, 1901.

Copies of any of these Specifications may be obtained of Messrs. W. P. Thompson and Co., 322, High Holborn, W.C., and at Liverpool, price, post free, 9d. (in stamps).

5,042. "Improvements in glow bodies for Nernst incandescent electric lamps." B. M. Drake, M. Solomon and Nernst Electric Light. Dated March 9th, 1901.

5,062. "Improvements in cord-controlled switches for electrical purposes." A. T. M. Thomson and Thomson-Davis Telephone System. Dated March 9th, 1901.

5,063. "Improvements in secondary batteries." T. T. A. Hansen and C. C. F. F. Petersen. Dated March 9th, 1901.

5,088. "Trolley head for electric tramcars." J. D. Russell. Dated March 11th, 1901.

5,121. "Improvements in insulating strips and cores for rheostats, electric heaters, and similar devices." P. M. Justice. Dated March 11th, 1901.

5,134. "Improvements in conduits for electric cables and the like." C. A. W. Hultman. Dated March 11th, 1901.

5,145. "A combined ozoniser, medical coil, and lamp-fed use for medical and other purposes." Electric Ozone Syndicate. Dated March 11th, 1901.

5,164. "An improvement in breaks for induction coils." J. Carpentier. Dated March 11th, 1901.

5,165. "An improvement in switches for varying electrical resistance." Siemens Bros. & Co., Ltd. Dated March 11th, 1901.

5,171. "Improvements in non-inductive resistances." W. du B. Duddell. Dated March 12th, 1901.

5,172. "Electrical thermal device for working switches, registering apparatus, and the like." G. Charlton and W. E. Barton. Dated March 12th, 1901.

5,204. "Improvements in apparatus for enamelling the surfaces of refractory metals." S. S. Bromhead. Dated March 12th, 1901.

5,220. "Improvements in electrical surgical dilators." C. L. Mosher. Dated March 12th, 1901.

5,247. "Improved switch for controlling electric motors." A. G. Bloxam. Dated March 12th, 1901.

5,263. "Improvements in receivers for electric demand indicators." A. Wright. Dated March 12th, 1901.

5,265. "Improvements in and relating to the recovery of precious metals by electrolysis." J. F. Webb. Dated March 12th, 1901.

5,292. "Improved system of guard wire protection for electric trolley or other high pressure uninsulated wires." E. W. Cowan, A. Still and T. L. Miller. Dated March 13th, 1901.

5,306. "Improvements in or connected with conductors, conduits and connectors for electricity on railways and the like." R. C. Sayer. Dated March 13th, 1901.

5,332. "Improvements relating to electro-therapeutic apparatus." A. W. Courtney. Dated March 13th, 1901.

5,343. "A method of apparatus for actuating demand indicators or other devices on public electric supply or distribution systems." A. Wright and Reason Manufacturing Co. Dated March 13th, 1901.

5,403. "Improvements in and relating to electric pendant lamps." R. H. Best. (Modification of that described in Specification No. 6,907, A.D. 1893.) Dated March 14th, 1901.

5,411. "Improvements in electric measuring apparatus." R. Ziegenberg. Dated March 14th, 1901.

5,460. "Improvements in and relating to prepayment meters for the supply of electricity." J. Finlayson and W. Scott. Dated March 15th, 1901.

5,487. "Improvements in electric heating and cooking apparatus." F. W. Schindler. Dated March 15th, 1901.

5,496. "Improvements in electric meters." E. Batault. Dated March 15th, 1901. (Date applied for under Section 103 of Patents, &c., Act, 1883, August 17th, A.D. 1900.)

5,510. "Improvements in commutator brushes and brush-holders for electric motors or dynamo-electric machines." R. Lundell. Dated March 15th, 1901.

5,516. "A process for metallising fabrics." C. Danilevsky, S. Tourchaninoff, A. Danilevsky and V. Timonoff. Dated March 15th, 1901.

5,560. "Improvements in and relating to devices for cutting out broken or short-circuited sections of trolley wires used in connection with electric traction systems." C. M. Dorman and R. A. Smith. Dated March 16th, 1901.

5,562. "Improvements in and relating to devices for cutting out broken or short-circuited sections of trolley wires used in connection with electric traction systems." J. W. Donaldson. Dated March 16th, 1901.

5,592. "An improved method of manufacturing filaments for incandescing electric lamp." W. L. Voelker. Dated March 16th, 1901.

5,700. "Improvements in or relating to electric clocks." J. Poschl and J. Gautsch. Dated March 18th, 1901.

5,713. "Improvements in electrical switches." H. Lomax, R. Lomax and J. Tomlinson. Dated March 19th, 1901.

5,719. "Improvements in bearings for trolley heads on electric tramcars." T. B. Birkby and F. E. Birkby. Dated March 19th, 1901.

5,766. "Improvements in the working and controlling of electrically-driven cars." Siemens Bros. & Co., A. Siemens, A. M. Duke. Dated March 19th, 1901.

5,786. "Improvements relating to telephone apparatus comprising conversation counters or meters." H. Eichwede. Dated March 19th, 1901.

5,791. "Improvements in and relating to electric incandescent lamps." R. A. Fessenden. Dated March 19th, 1901.

5,906. "Improvements in electrical heating apparatus." R. W. Boyd. Dated March 20th, 1901.

5,952. "An improved watertight cover for electric cut-outs, switches, joint boxes, and the like." H. Hirst and T. H. Bacon. Dated March 21st, 1901.

5,985. "Improvements in and relating to current collectors for electric railways on the overhead system." A. Reinecke and A. Jost. Dated March 21st, 1901.

5,986. "Improved armature core for electric generators." G. Koppelmann. Dated March 21st, 1901.

6,004. "Improvements in means or apparatus for driving dynamos on railway and other vehicles from the axles thereof." F. J. Beaumont and W. M. Still. Dated March 21st, 1901.

6,042. "Improvements in printing telegraphs." L. Kamm. Dated March 22nd, 1901.

6,043. "Trolley conductor insulated fitting for electric tramways and railways." F. G. Kleinsteuber. Dated March 22nd, 1901.

6,095. "Improvements in transformers and the like." W. E. Burnand. Dated March 23rd, 1901.

6,102. "Improvements in anodes." A. F. Harris. Dated March 23rd, 1901.

6,107. "Improvements in electrical measuring instruments." A. C. Heap and W. O. Smith. Dated March 23rd, 1901.

6,161. "Method of and apparatus for controlling single-phase alternate current motors." Siemens Bros. & Co. and F. Lydall. Dated March 23rd, 1901.

6,207. "Improved method of and means for automatically switching off the current in trolley wires used for electric traction, in case of a breakage or other accident." R. Swales, F. Stamford and R. A. Swales. Dated March 25th, 1901.

6,242. "Improvements in or connected with electric demand indicators." W. Cowderoy. Dated March 25th, 1901.

6,258. "Improvements in electrical switches and like contact devices." J. J. Glass. Dated March 25th, 1901.

6,261. "Improvements in liquid rheostats operated by means of compressed air." C. de Kando. Dated March 25th, 1901.

6,352. "Improvements in electric accumulators." B. M. Drake and J. M. Gorham. Dated March 26th, 1901.

6,353. "Improvements in and relating to electrically-driven rotary pumps." B. M. Drake and J. M. Gorham. (Drawings to specification; grant of patent opposed.) Dated March 26th, 1901.

6,402. "Improvements in automatic circuit electric circuit breaker." A. Eckstein and D. B. Mellis. Dated March 27th, 1901.

6,445. "Improvements relating to switch mechanism more especially applicable for use in electric motors." H. Lamm. Dated March 27th, 1901.